The
ENGINEERS' DIGEST

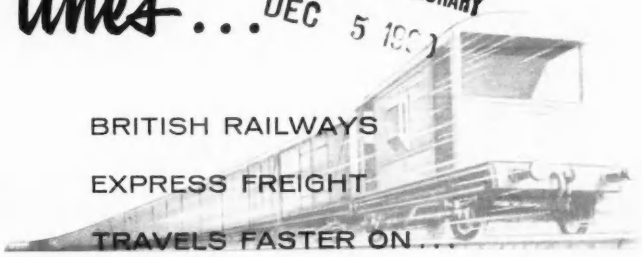
A World Review of
DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXI No. 11 NOVEMBER, 19

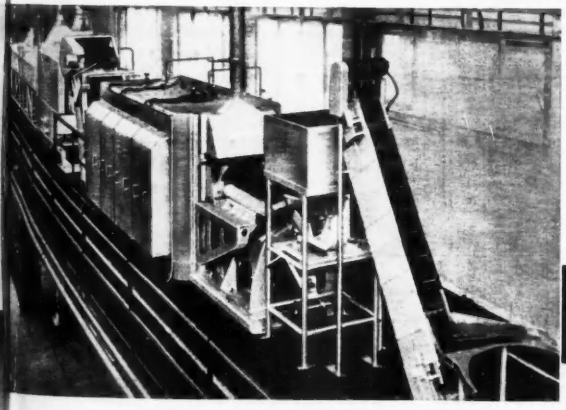
THE JOHN CRERAR LIBRARY
DEC 5 19

620 X-1

On the right lines...



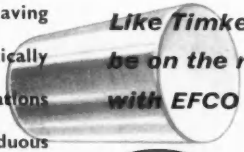
BRITISH RAILWAYS
EXPRESS FREIGHT
TRAVELS FASTER ON...



TIMKEN
tapered roller bearings
who use

EFCO
HEAT TREATMENT PLANT

At British Timken, rollers have their own line — an EFCO continuous production line — where having been previously carburised they are automatically hardened and tempered to the precise specifications necessary for them to perform their arduous duties for British Railways.



Like Timken
be on the right lines
with EFCO

EFCO FURNACES
the best of the world's furnace designs

NRP/R3062

ELECTRIC RESISTANCE FURNACE CO. LTD
NETHERBY, QUEENS ROAD, WEYBRIDGE, SURREY · Weybridge 3891
Associated with Electro-Chemical Engineering Co. Ltd.

CALDWELLS OF BOLTON FOR STAINLESS STEEL

Chemical Plant,

Mixing Vessels,

Storage Vessels,

Tanks, Ducting,

Piping, Flanges.

SPECIALISTS IN STAINLESS STEEL AND MILD STEEL FABRICATION.

CONSTRUCTIONAL STEELWORK.

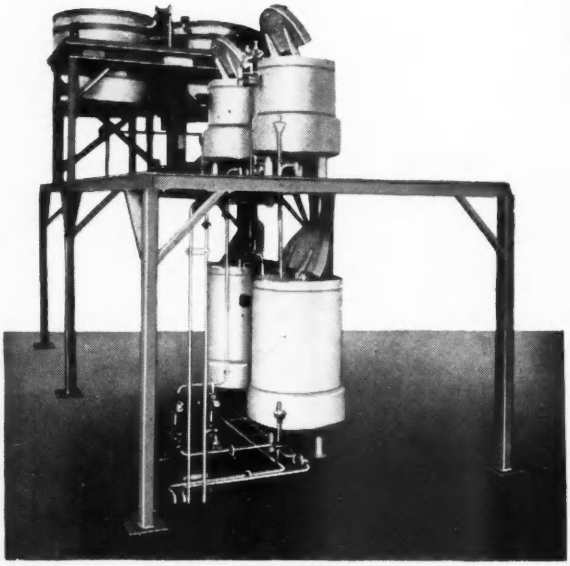
CAPSTAN AND REPETITION WORK.

SEND YOUR ENQUIRIES TO:

T. CALDWELL & SON

ST. JOHN STREET, BOLTON

Est. 1877 Phone BOLTON 3672 (2 lines)



"Cronite" REGD. TRADE MARK

now WRITE FOR A NEW BOOKLET

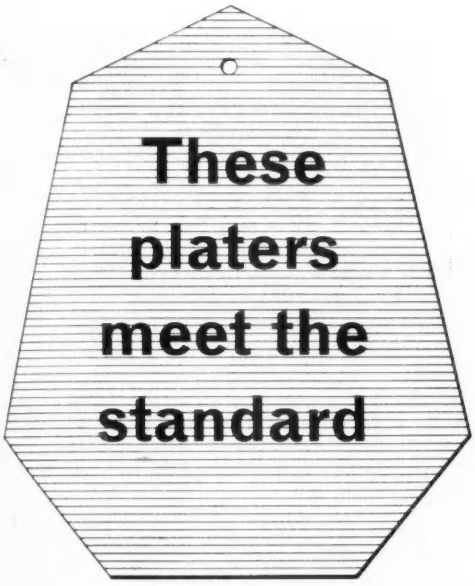
The HIGH TEMPERATURE ALLOY

SALT, LEAD AND CYANIDE VESSELS
CARBURIZING BOXES AND POTS
ROTARY RETORTS & PROPELLING WORMS
FURNACE HEARTHS AND FITTINGS
ENAMELLING PERRITS AND SUPPORTS
GLASS-BLOWING NOZZLES
PYROMETER PROTECTION SHEATHS
CASTINGS FOR USE AT 700 1200 C.

The **CRONITE FOUNDRY Co, LTD**

LAWRENCE RD·TOTTENHAM·LONDON.N15

PHONE·STAMFORD HILL 4237



To date these out-platers have joined the MOND LABELLING SCHEME and will supply manufacturers with certified work plated to the requisite grade of the BRITISH STANDARD 1224:59

LONDON AND HOME COUNTIES

ABBEY PLATING WORKS LIMITED
Wycombe Road, Beresford Avenue, Wembley, Middlesex
AMALGAMATED PLATING WORKS LTD
28-32 Britannia Street, WC1
ATLAS PLATING WORKS LTD
79 Avenue Road, Acton, W8
B. BERGER AND CO LTD
Tonbridge Road, Harold Hill, Romford, Essex
CU-NI-CRAFT LIMITED
Hanworth Trading Estate
Hampton Road West, Feltham, Middlesex
ESSEX PLATING CO LTD
Elm Grove, Wimbledon, SW19
GERHARDY BROS LTD Gt. Missenden, Bucks
THE HARRIS PLATING WORKS LTD
18 New Wharf Road, N1
HOLMES PLATING CO LTD
Blackheath Grove, SE3
HORLEY ENGINEERING AND PLATING CO LTD
Smallfield Road, Horley, Surrey
W. HORWOOD AND SON LTD
774-6 Seven Sisters Road, Tottenham, N15
JUNO PLATING
Stock Road, Southend-on-Sea, Essex
LETCHWORTH POLISHING AND PLATING CO LTD
Works Road, Letchworth, Herts.
METAL COLOURS (SLOUGH) LTD
353/354 Oxford Avenue, Slough Trading Estate, Slough
J. METCALFE (PLATERS) LTD
735 Old Kent Road, SE17
MITCHAM PLATING CO LTD
37-39 Western Road, Mitcham, Surrey
MURRIVAN LTD 99 Tamworth Road, Croydon, Surrey
Q.B.E. PLATING CO LTD 48 Strafford Road, Acton, W3
STONE'S PLATING CO LTD
10a-12a, Ernest Avenue, West Norwood, SE27
R. A. SWINNARD
North Farm Road, High Brooms, Tunbridge Wells, Kent
JOHN WILKINS AND CO LTD
231/243 St John Street, EC1

WEST & SOUTH

ADDY PRODUCTS LTD
Millbrook Trading Estate, Southampton, Hants
THE BUCKFAST PLATING CO LTD Buckfast, South Devon
E. J. M. (PLATING) LTD Newport Road, Cardiff
ELECTROCHROME LIMITED
York Road Trading Estate, Bridgend, Glam.
EXETER IGNITION CO LTD Summerland Street, Exeter
GLOUCESTER PLATING CO LTD
Eastern Avenue, Gloucester
KIMBERLEY & HOGG LTD
Brimscombe Mills, Stroud, Glos.
MAGRATH METAL FINISHING CO LTD
Penarth Road, Cardiff
A. T. POETON & SON LTD Tower Hill, Bristol
SOMERSET METAL CRAFTS LTD
89 Station Road, Taunton, Somerset

MIDLANDS

BRITACHROME CO LTD
Cope Street, Birmingham 18
THE BROADWAY CHROMIUM PLATING WORKS
94 Alcester Street, Birmingham 12
DIAMOND CHROME PLATING CO LTD
Elenora Street, Stoke-on-Trent
W. T. FROST LTD
5, 6, 7 Harford Street, Birmingham 19
HALFORD POLISHING AND PLATING CO LTD
Ford Street, Smethwick 41
A. F. HAYES AND CO Wigston, Leicester
IONIC PLATING COMPANY LTD
Grove Street, Birmingham, 18
NORTHAMPTON AND MIDLAND PLATING CO LTD
6 Connaught Street, Northampton
K. & S. PLATING CO LTD
5 Vaughton Street, Birmingham 12
THE PREMIER PLATING CO LTD
1-9 Barr Street, Birmingham 19
B. J. ROUND & SONS LTD
7-10 Northampton Street, Birmingham 18
SNELL AND PRIDEAUX LTD
20-22 Exeter Passage, Holloway Road, Birmingham 1
WARSTONE POLISHING CO LTD
183 Warstone Lane, Birmingham
WILKES & GODWIN LTD
Charles Henry Street, Birmingham 12
WOLVERHAMPTON PLATING CO LTD
Anchor Lane, Coseley, Bilston, Staffs.

NORTHERN ENGLAND

SAMUEL ALLEN 109 New Bridge Street, Newcastle
THE BARNSLEY ELECTROPLATING CO LTD
Chesham Road, Barnsley
BRAILEY ELECTROPLATERS LTD
Chapel Street, Salford 3, Lancs
DYECHROME LIMITED Ashley Lane, Shipley, Yorks.
A. ELLIOTT (ELECTROPLATERS) LTD
Stowell Street, Newcastle-upon-Tyne 3
KING & FOWLER LTD
Jamaica Street, Liverpool 1
OCTOPUS LIMITED Goodall Place, Liverpool 4
TOWNHEAD CHROMIUM PLATING CO
16-18 Whitworth Road, Rochdale, Lancs

NORTHERN IRELAND

LYNESS BROS LTD
1 North Howard Street, Belfast
SERCK RADIATOR SERVICES LTD
308 Albertbridge Road, Belfast

SCOTLAND

CHARLES CARPENTER LTD
Muirhall Road, Larbert, Stirlingshire
VERICHROME PLATING SERVICES (SCOTLAND) LTD
Industrial Estate, Larkhall, Lanarkshire

Contact one of these platers—and be sure that you can safely display the important Label of Plating Quality on your product.

Good plating is good business

Use quality labels on your chromium plate

SEND FOR DETAILS

THE MOND NICKEL COMPANY LIMITED · THAMES HOUSE · MILLBANK · LONDON · SW1

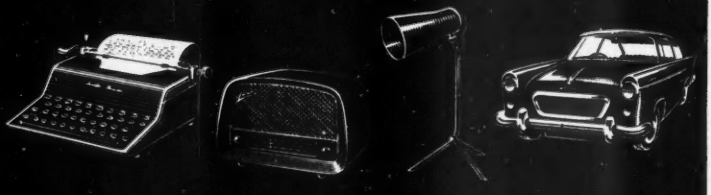
TGA P4

BRYMILL

PLASTIC COATED STEEL STRIP

BEAUTY

Plastic Coated Steel Strip has numerous possible applications and for this reason is being produced in a wide range of textures and colours. Write for further details.



FOR NEARLY HALF A CENTURY

BRITISH ROLLING MILLS LIMITED

BRYMILL STEEL WORKS P.O. BOX NO. 10 TIPTON, STAFFS.

CONTENTS

	Page
The Minidigest	4
Business Notes	10
Contracts	12
Personal	16
News Round-up	20
Letters to the Editor	24
New Technical Books	26
Latest Industrial Literature	28
The Blue Pages	73
The Mechanical Restraint of Shrinkage in Castings Made in Metallic Moulds	81
Properties and Applications of Glass-Ceramics	85
X-Ray Inspection of Hot Steel Billets during Rolling	87
New Developments in Ni/Ni-Cr Thermocouples	88
Improved Design of Anodo-Mechanical Sawing Machine	90
Investigation into the Development of Wrought Cobalt-Tungsten Base Alloys	91
Progress in the Engineering Applications of Plastics	97
British Industrial Developments	119
Additional Abstracts	125
New Materials, Processes, and Equipment	131
Index of Advertisers	173

The ENGINEERS' DIGEST

A World Review of DESIGN & PRODUCTION · RESEARCH & DEVELOPMENT

VOL. XXI No. 11 NOVEMBER, 1960

EDITORIAL AND ADVERTISING OFFICES:

GREAT BRITAIN
120 Wigmore Street, London, W.1.
Telephone: WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone: MUrray Hill 2-8865

FRANCE
102 Rue Amelot, Paris (XI^e)
Telephone: VOL. 29-19

ITALY
Via degli Orombelli 13, Milan
Telephone: 23.16.72

Annual Subscription Rates:
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by Williams, Lea & Co. Ltd., Clifton House, Worship Street, London, E.C.2. and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

GUIDE TO THE SPACE AGE

Compiled and Edited by C. W. Besserer and Hazel C. Besserer.

First published in America "Guide to the Space Age", is a comprehensive presentation of the terminology of space technology in dictionary form. Terms are authoritatively defined covering as broad an area as possible and many cross-references, drawings and diagrams are included. The importance of this book will be obvious to those working in this field. 47/6 net.

ENCYCLOPEDIC-DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING

By Robert I. Sarbacher.

The first and only encyclopedic dictionary to include all terms, equipments, elements, components and systems. The outcome of twelve years' meticulous research it forms a massive, inexhaustible compilation of the latest scientific information in these rapidly changing and expanding subjects. £8 net.

PRINCIPLES & CONSTRUCTION OF AIRCRAFT GAS TURBINES

By R. A. Fry, A.R.Ae.S., M.S.L.A.E.

This new work deals with the elementary theory, the constructional principles, the operational problems and the practical maintenance and inspection of modern aircraft power plants. 50/- net.

VARIATIONAL PRINCIPLES IN DYNAMICS AND QUANTUM THEORY

By Wolfgang Yourgrau, Dr.Phil., and Stanley Mandelstam, Ph.D.

Second Edition.

This book is of particular value to students in their final year's honours course in mathematical physics but it is of great interest to physicists and mathematicians all over the world. In this second edition the book has been enlarged to include a new chapter on the Feynman and Schwinger principles in quantum mechanics, and a paper by Wolfgang Yourgrau and C. J. G. Raw on variational principles and chemical reactions. 32/6 net.

From all booksellers

PITMAN

Parker St., Kingsway, London, W.C.2

The

MINIDIGEST

A brief note in *Machine Design* for August 18, 1960, states that a **new technique for producing hard-to-combine metals,** such as copper/silver, germanium/silver, and gallium antimonide/germanium, has been developed at the California Institute of Technology. In this technique, mixing is accomplished by what is designated "splat cooling", in which the molten metals are splatted against the rim of a rapidly rotating wheel kept at a temperature of −300°F, cooling of the molten metals being effected at an equivalent rate of 2,000,000°F per second.

* * *

A new type of **grid-control cold-cathode discharge tube** has been developed for use as a relay for telephone-switching applications at the Tokyo Laboratories of the Nippon Telegraph and Telephone Public Corporation. In this tube, five electrodes are mounted in a miniature bulb filled with 95% neon and 5% argon at a pressure of 80 mm Hg, the principle of operation being similar to that of a hot-cathode thyratron. The tube can be triggered by a low-level signal and, owing to low heat dissipation, its life with a cathode current of 60 mA is about 18,000 hr. However, as the tube can be operated under stand-by conditions with lower currents, its actual life is expected to be considerably longer.

* * *

Details of recent investigations carried out in Russia into the **high-speed filling of acetylene cylinders** are reported in *Svarochnoye Proizvodstvo* for August 1960. The results of these investigations have shown that, if the cylinders, during filling, are sprayed with water at a temperature between 4° and 8°C, the pressure in the cylinder can be increased to as much as 22 kg/cm². In addition, filling speed is greatly increased; for example, whereas the filling of a 40-litre cylinder by conventional methods takes about 8 hr, the use of water-cooling reduces the filling period to about 3 hr.

* * *

Making it possible to study in detail how materials stretch and break when pulled apart in the temperature ranges encountered in outer space and in the fuelling of rockets with liquefied gases, a special cryostat recently developed by Arthur D. Little, Inc., of Cambridge, Mass., permits the **determination of the tensile strengths of materials at temperatures near absolute zero.** The cryostat comprises two parts, i.e., a cooling

HALLMAC TOOLS LIMIT
LONDON: Suite 418, Cayzer House, 2/4 St. Mar
London, E.C.3. *Telephone AVEnue* 5792
SALES MANAGERS FOR

The HALLMAC of Success

The most successful answer to the tool supply problem is to order all tool requirements from one source—provided that source is 100% efficient and comprehensive. Hallmac's immense stock of Engineer's Small Tools, Hand and Power Tools, and Macrome treated tools is supported by a distribution and service network that covers the whole country. This means immediate service on standard requirements; even on "specials" an *almost* immediate response. This is the Hallmac of Success, enabling you to iron out all your buying difficulties with one simple, sensible decision: Tools from Hallmac. To give you an idea of the range we cover, may we send you a copy of the latest 48 page Hallmac Stock List, now recognized as the foremost of its kind?

Office & Depot: **P.O. Box No. 39, Macrome Road, Wolverhampton.** *Telephone 52001 (9 lines)*

MANCHESTER: 1 Lloyd Road, Manchester 19
Telephone: Heaton Moor 3255

GLASGOW: Central Chambers, 11 Bothwell Street, C.2
Telephone: CENtral 5066

TOOL DIVISION OF THE BREN MANUFACTURING COMPANY

IW.Ad 4747

The MINIDIGEST

chamber and an automatic measuring device, the chamber being refrigerated to 4·2°K by means of liquid nitrogen and liquid helium. Two pairs of sliding calipers inside the chamber scan the dimensional deviations of the specimen during stress applications and relay the measurements to a computer-recorder, which then plots a stress/strain curve. In tests carried out to date, the measuring device has proved accurate to within $\pm 0{\cdot}001$ in.

* * *

Studies under way at the Bell Telephone Laboratories, New York, indicate that a **new thermo-electric material,** silver antimony telluride ($AgSbTe_2$), is one of the most efficient of its kind yet developed. This compound is reported to have a thermo-electric figure of merit Z of about $1{\cdot}75 \times 10^{-3}$/°C over a range of temperatures between 200° and 500°C, and, as such, is the best yet observed for *p*-type thermo-elements in this range. The material, which has a disordered cubic structure, exhibits a thermal conductivity as low as 0·0064 W/cm-°C at room temperature, i.e., only 1% that of germanium. While it is always thermo-electrically *p*-type, its Hall effect is *p*-type in some specimens and *n*-type in others, even when taken from a single ingot. Studies of this and other anomalies are in progress and are expected to advance considerably knowledge of semiconductors.

* * *

According to *Werkstoffe und Korrosion* for October 1960, investigations have been carried out in Germany into the possibility of **improving the corrosion resistance of flame-sprayed alumina coatings.** On the basis of tests on steel specimens sprayed at a distance of 8 to 10 cm from the gun with alumina having a grain size of 10 to 15 microns, it has been established that, despite the low porosity of the sprayed coatings, they do not offer complete high-temperature protection against corrosion. Their protective effect can, however, be greatly increased by using an intermediate metal or enamel layer on the surface to be treated or by stabilizing the sprayed coatings with lithium oxide.

* * *

In a lecture forming part of the recent Symposium on Transformers, held at The English Electric Co. Ltd., Stafford, it was pointed out that, although a terylene type of material designated "Melinex" appears to fill

FACTS AND FRICTION

Look at the construction of a FLEXHOISTA—6 strands each of 19 wires with an independent wire rope core, all perfectly assembled yet all working independently to give flexibility.

They are continually subjected to both external and internal stresses and strains and to surface abrasion and pressure; these changes are taking place very rapidly when the rope is running. That is why it is so important to get the right rope for the job.

FLEXHOISTA is made by a Company with close on a century of experience and service in ropes.*

*For scheduled replacement, emergency or just honest advice about wire ropes—call in Whitecross any time.

FIT THE ROPE FIT FOR THE JOB - FIT

FLEXHOISTA

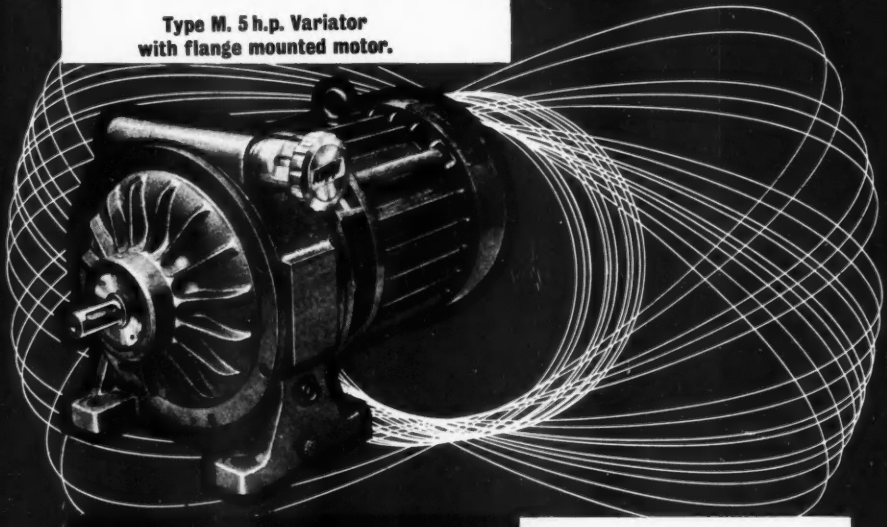
REMEMBER POPPY DAY

THE WHITECROSS COMPANY LIMITED
WIRE ROPES
WARRINGTON, ENGLAND. EST. 1864

- Range 1/33 h.p. to 15 h.p.
- 9 to 1 stepless speed variation.
- Constant power transmission.
- Flange mounted motors (when required).
- Flange mounted Reduction Gears for low output speeds.
- Exceptionally light, sensitive and accurate control of speed settings by handwheel, pneumatic, mechanical or electrical remote control.
- Service reliability resulting from a simple design.
- Compact, vibrationless and silent.

A GEARLESS GEARBOX

Type M. 5 h.p. Variator with flange mounted motor.



Kopp

VARIABLE SPEED GEARS

LONDON
59 PARK ROAD NORTH, ACTON, W.3
TELEPHONE: ACORN 7150

SCOTLAND
P.O. BOX No. 1, CLARKSTON, GLASGOW
TELEPHONE: BUSBY 2738

MIDLANDS
CRUSADER HOUSE, 24 LIVERY ST.,
BIRMINGHAM, 3
TELEPHONE: CENTRAL 8897

YORKSHIRE
MIDLAND WORKS,
CANAL ROAD, LEEDS 12
TELEPHONE: 630551

ALLSPEEDS LIMITED
142, ROYAL WORKS, CLAYTON-LE-MOORS, P.O. BOX 43, ACCRINGTON, LANCS. TEL.: ACCRINGTON 35441 (6 LINES)

The MINIDIGEST

the need for a new transformer insulation which combines a better space factor than paper with superior insulating properties, problems can arise in applying Melinex to the conductor, as oil cannot penetrate it, so that air voids may be formed, with consequent corona discharge. It was also pointed out, however, that these difficulties have been overcome by a **new method of using Melinex terylene in combination with paper as a conductor insulator for transformers.** This patented method, which has been developed by The English Electric Co. Ltd., involves the insertion of a U-shaped piece of Melinex under the last layer of paper insulation, adjacent conductors having the Melinex inserted with the "U" upright and alternately inverted. Oil impregnation takes place through the open end of the "U", and maximum creepage distance is provided between adjacent conductors.

* * *

As reported briefly in *Product Engineering* for September 26, 1960, a process of producing **greaseless, corrosion-free, gall-resistant zirconium bearings** which are claimed to be dimensionally stable and which can be used in high-temperature water and steam has been patented by a Canadian nuclear engineer. The basic principle of the process is the formation, by controlled oxidation, of a blue-black zirconium dioxide surface layer on the bearing body, and this treatment can be accomplished by exposing the bearings to air, oxygen, steam, or hot water at temperatures between 1300 and 1650° F.

* * *

Brief details are contained in *Machine Design* for September 1, 1960, of a new method of metal forming under development by several aircraft companies. Designated **electromagnetic forming,** the new method should permit heat-treating, forming, and even cutting to be carried out more easily and cheaply than by conventional methods and can be applied to most metals. In fact, the better conductor is the metal, the more easily it forms. Generating over 50,000 psi in 0·001 sec, the magnetic force handles the metal in much the same way as in explosive forming, but has the major advantage of being much safer, so that it can be used indoors. The workpiece contains no residual magnetism. The main problems still to be solved are the switching circuits for the very high electric currents required, and the construction of coils massive enough to withstand the forces involved.

appointment with the future...

MEN WANTED for Hazardous Journey. Small wages, bitter cold, long months of complete darkness, constant danger, safe return doubtful. Honour and recognition in case of success — Ernest Shackleton.

This classified advertisement appeared in London Newspapers in the year 1900 and, according to Shackleton, he was overwhelmed by the replies. We are not surprised.

In every age there are always men and women who will come forward to answer the call of the unknown and the dangerous.

But it isn't just in going to one of the Poles, climbing Everest, or going to the nearer planets. New ground can be broken and fresh discoveries made by staying at home, taking thought and refusing to accept the apparently obvious. Whether it's exploring new territory in research, following a stimulating line of enquiry, playing with ideas and translating them into practical realities ... this is the very stuff of technical progress and scientific advancement.

We think this way at Balfour's. The quality of our Engineer's Tools is the result of creative competence and industrial initiative. From the raw materials to the finished article, Balfours Reamers, Cutters, Twist Drills and Engineers Tools of all kinds are the products of the most advanced and specialised technology grounded on continuous research.

STEEL & TOOLS FOR THE WORLD

ARTHUR BALFOUR

ARTHUR BALFOUR & CO. LTD., CAPITAL STEEL WORKS, SHEFFIELD, ENGLAND
ASSOCIATED COMPANY: THE EAGLE & GLOBE STEEL CO. LTD.

BUSINESS NOTES

The **Northern Aluminium Co. Ltd.** has now changed its name to **Alcan Industries Ltd.** The new name does not involve any change of ownership, manufacturing activity, or sales policy, its purpose being merely to identify the company clearly as a member of the **Aluminium Limited of Canada** (ALCAN) enterprise.

* * *

Redifon Ltd., a company in the Rediffusion Group, announces the establishment in the U.S.A. of **Redifon Electronic Inc.**, at 5265 Watson Street N.W., Washington.

* * *

The analytical-instrument activities of **Southern Instruments Ltd.**, of Camberley, Surrey, will in future be carried out in the name of **Southern Analytical Ltd.**, a company which has been newly formed for this purpose. Members of the board will include Mr. W. B. Horner (general manager), Mr. H. M. Davis, B.Sc., A.R.I.C., A.Inst.P. (chief engineer), and Mr. J. A. Colls, A.R.C.S., B.Sc. The chairman is Mr. Philip Sellars, vice-chairman of Southern Instruments Ltd.

* * *

British Insulated Callender's Cables Ltd. announce that the telephone number of their Middlesbrough branch has now been altered to Middlesbrough 43256/7/8.

* * *

The entire business and premises of **The Compressor & Demolition Co. Ltd.**, of 70-74 Stewart's Road, London, S.W.8, have been acquired by **C. H. Johnson (Machinery) Ltd.**, of Adswood, Stockport. In addition to maintaining their usual services, the Compressor & Demolition Company will retain and develop their existing services for the hire of their fleet of mobile and portable compressors, and also their concrete-demolition business. Mr. J. S. Mandel is retaining his position as director and manager of the company, and Mr. C. Mandel is remaining in charge of the offices.

* * *

Vokes Limited has changed its name to **Vokes Group Limited,** and a new subsidiary company has been incorporated to take over the business and trading of Vokes Ltd. as previously. The board of Vokes Group Limited remains unchanged, and the board of the new operating subsidiary is Sir Ian Stewart-Richardson, Bt. (chairman), Mr. H. F. Osborne (vice-chairman and managing director), Mr. C. E. M. Hardie, O.B.E., F.C.A., Mr. D. F. Ringe (general manager), Mr. J. Phillips, F.C.A., (secretary), and Mr. A. E. Queening, F.C.A. (assistant secretary).

* * *

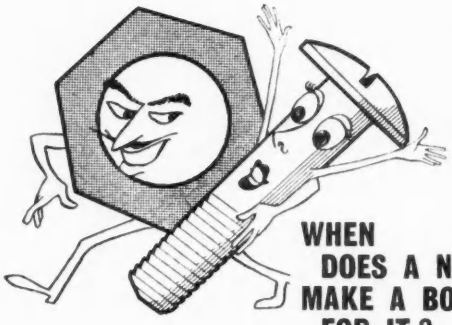
A long-term agreement has been concluded between **The General Electric Co. Ltd.**, of London, W.C.2, and **Nippon Denkyoku Kabushiki Kaisha** (Nippon Electrode Co. Ltd.), covering the manufacture in Japan of two special types of graphite developed by G.E.C. for use in nuclear plant, one of low permeability, and the other substantially impermeable. Under the terms of the agreement, which is initially for a period of ten years, G.E.C. will pass on to Nippon Denkyoku all information on the manufacturing processes involved and will assist the Japanese company to set up the necessary plant. In addition, G.E.C. will provide technical staff to help with the building of the new plant.

* * *

The **Pressed Steel Co. Ltd.** announce that they are taking steps to form a subsidiary company, to be known as **British Executive and General Aviation Ltd.** (BEAGLE), which will concentrate on the design and manufacture of a new range of executive and light aircraft for the home and export markets. To this end, Pressed Steel is acquiring the whole of the share capital of **Auster Aircraft Ltd.**, the intention being to continue the production and further development of the existing Auster range of light aircraft. At the same time, a technical and manufacturing liaison has been arranged with **F. G. Miles Ltd.**, of Shoreham Airport. In addition, the new group of companies is entering into discussions with **Rolls-Royce Ltd.**, in connection with a series of Rolls-Royce powerplants for this class of aircraft.

* * *

Sheepbridge Engineering Ltd., of Chesterfield, have purchased for cash the issued share capitals of the **Purfection Engineering Co. (Coleshill) Ltd.**, manufacturers of splines and all forms of precision ground tools and gauges, and of its associated company, the **Station Engineering Co. (Coleshill) Ltd.**, who manufacture Fulmer honing machines under licence.



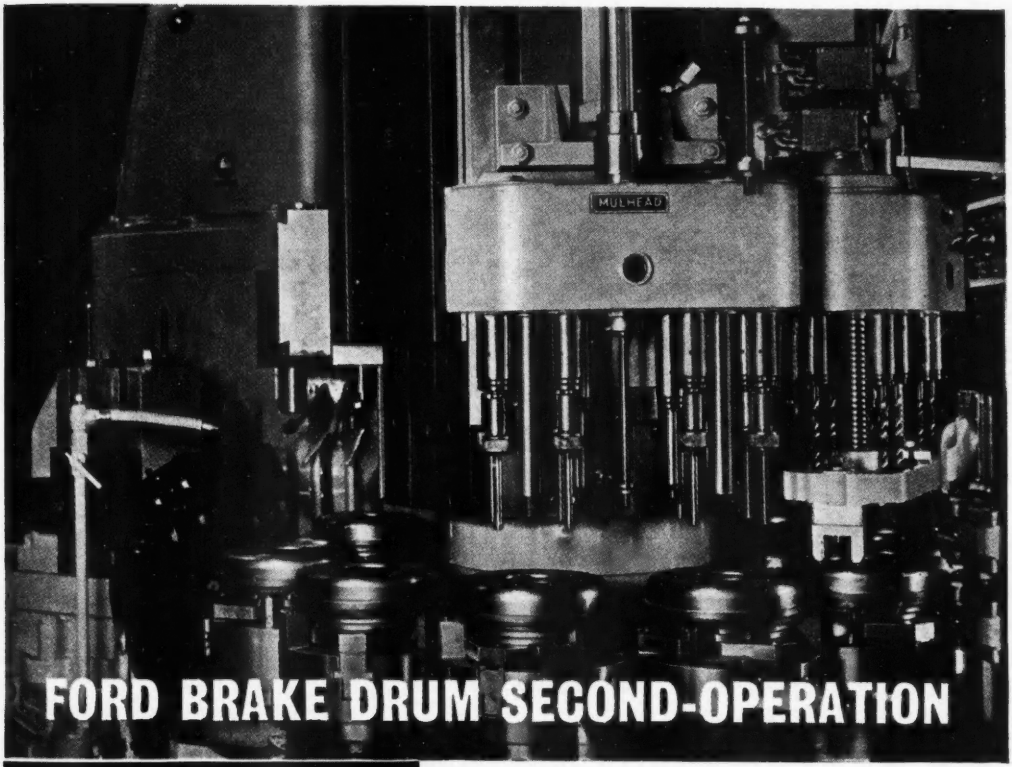
WHEN DOES A NUT MAKE A BOLT FOR IT?

. . . when component manufacturers discover that the Lewis Spring Company can design and produce almost any kind of spring clip fastening. Spring clip fastenings can do the job more efficiently than older methods, so start cutting assembly costs now. Consult the Lewis Spring design department — it costs nothing to ask.

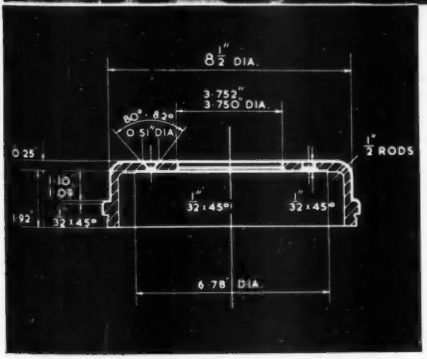
* Send 2/6 postal order for our 40 page booklet on spring design with full technical data. It is an invaluable reference for your design department.

THE LEWIS SPRING CO. LTD.
RESILIENT WORKS, REDDITCH
London Office
122 High Holborn, W.C.1

LEAVE IT TO **Lewis** OF REDDITCH
SPRINGS, PRESSWORK AND WIRE FORMS TO FINE LIMITS



FORD BRAKE DRUM SECOND-OPERATION



MACHINED IN 40 SECONDS

The use of special Mulhead multi-drill heads on the Ryder Verticalauto enables drilling, reaming, countersinking and back-chamfering operations to be performed in addition to standard boring and facing work.

The second operation on this Ford Brake Drum is completed at very high output rates on this 12-spindle No. 10 Ryder Verticalauto.

Ryder ***VERTICALAUTO***

Thos. Ryder & Son, Limited, Turner Bridge Works, Bolton, England.
Makers also of single spindle Rydermatics and Piston Ring Lathes.

CONTRACTS

A contract valued at more than £500,000 has been awarded to Associated Electrical Industries Ltd. for the supply and installation of 33-kV and 11-kV cables for the new Spencer steelworks, which is being constructed by Richard Thomas & Baldwins at Newport, South Wales.

* * * *

A contract for a flash steam plant, valued at £150,000, has been obtained in the face of international competition by Bennis Thermoflash Ltd., of Little Hulton, Walkden, Manchester. The plant is for the New Zealand Government and will form part of the geothermal project at Wairakei on the North Island.

* * *

It is announced by the Leyland Motors Group that they have received a contract valued at £400,000 from the Municipality of Teheran for re-equipping the city's street-cleansing and refuse-collection system. The order includes 45 Leyland "Super-Comet" 14-ton vehicles, 37 Scammell "Scarab" 6-ton mechanical horses, and 2000 handcarts complete with 4000 dustbins.

* * *

The first multi-zone, fully air-circulated, radiant-tube soaking pits in Great Britain have been ordered from Stordy Engineering Ltd., of Wolverhampton, by James Booth Aluminium Ltd. for installation in their Kitts Green Works, Birmingham. These soaking pits will be used in conjunction with James Booth's 148-in., four-high hot reversing mill, which is the largest of its type in Western Europe and which will be installed during the second half of 1961. The £80,000 order includes the design, supply, and installation of two pits, each with a working area of 23 ft 6 in. × 7 ft 6 in. and a depth of 14 ft to the underside of the lid. The total capacity of the two pits will be 120 tons of aluminium, with working temperatures up to 620°C. The contract also includes pit covers and electro-hydraulic travelling-girder-type cover-lifting gear.

* * *

The Racal Organization, of Bracknell, Berkshire, announce that they have received three major orders, totalling £560,000, through their agents in Canada (Instronics Ltd., of Stittsville, Ontario), covering installation equipment for Canadian vehicle-borne military radio stations. This equipment, which has been ordered by the Department of Defence Production, has been designed by Racal in collaboration with the Signals Research and Development Establishment, and consists of control and distribution boxes for the radio sets and intercommunication systems of the vehicles, together with microphones and telephones.

* * *

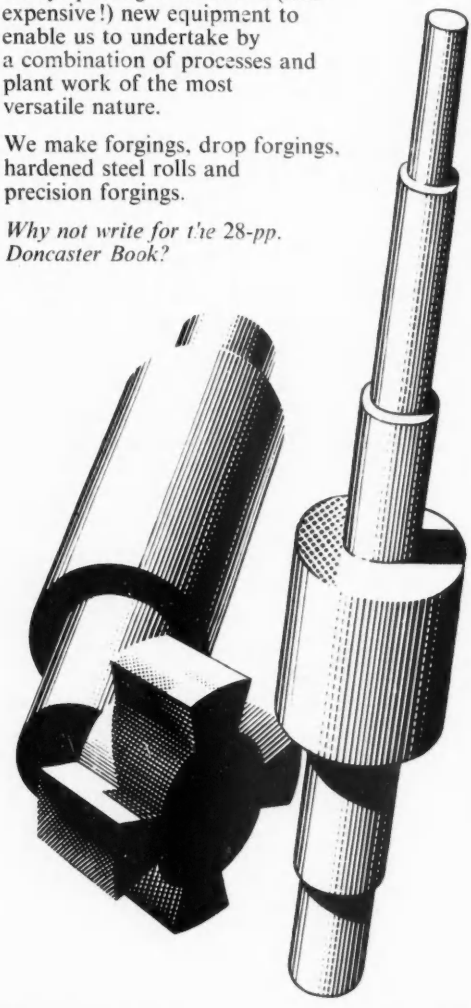
Following a contract for five heavy plate roller levellers for the new plate mills at the South Durham Steel & Iron Co. Ltd., and at the Consett Iron Co. Ltd., the Head Wrightson Machine Co. Ltd., a subsidiary of Head Wrightson & Co. Ltd., have received from Colvilles Ltd.

Famous for Forgings

The Daniel Doncaster companies never stand still—we are always putting in extensive (and expensive!) new equipment to enable us to undertake by a combination of processes and plant work of the most versatile nature.

We make forgings, drop forgings, hardened steel rolls and precision forgings.

Why not write for the 28-pp. Doncaster Book?



DONCASTERS ◇ *1778* D D

DANIEL DONCASTER & SONS LIMITED SHEFFIELD

MONK BRIDGE IRON & STEEL COMPANY · LEEDS 12
MOORSIDE COMPONENTS · OLDHAM
DANIEL DONCASTER & SONS (THE BLAENAVON CO. BRANCH) LTD. BLAENAVON · MONMOUTHSHIRE

F 32

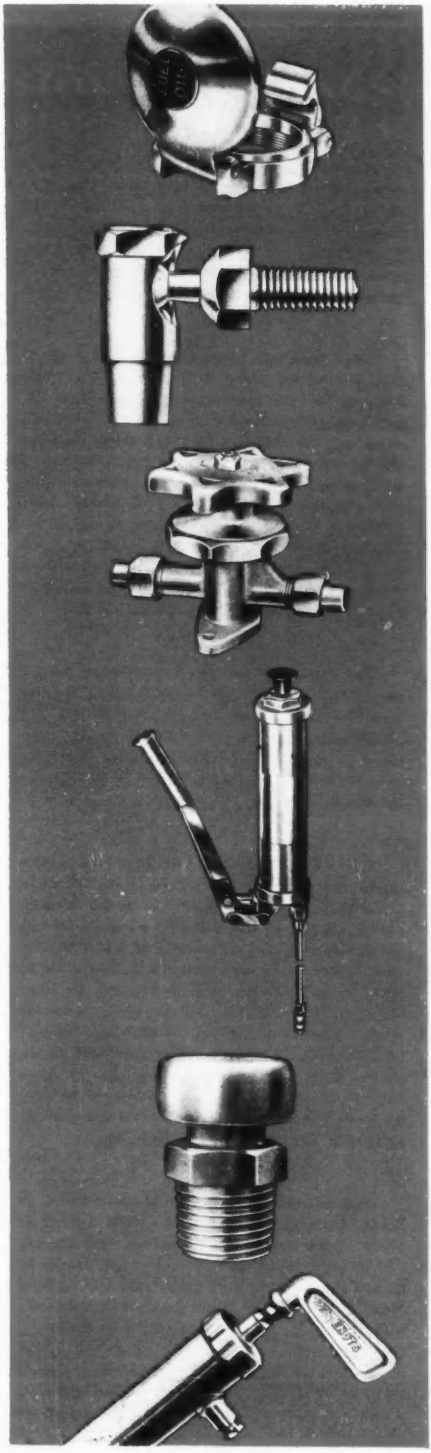
There is no end

TO THE COMPREHENSIVE RANGE OF

Enots

FITTINGS & ACCESSORIES serving almost every Industry

If we placed an advertisement on every page of this journal we still wouldn't be able to illustrate and specify all the fittings and accessories now incorporated in Enots range of products which include One Shot, Benston and Mechanical Centralised Lubricating Systems, Grease Guns and Nipples, Pressure Oilers, Filters, Coolant Fittings, etc. Control Valves, Air Cylinders, Lubricators, Flow Control, Valves, Solderless Pipe Fittings, Copper, Nylon and Bundy Steel Tube, Flexible Hoses, Fuel Cocks, Filler Caps, Throttle Control Ball Joints, Breathers, Sump Pumps, etc. Fortunately we are able to produce at a moment's notice, the appropriate catalogue adequately covering a customer's particular enquiry. We should like to hear from you.



Enots

BENTON & STONE LIMITED
ASTON BROOK ST. BIRMINGHAM 6
Telephone ASTon Cross 1905 Telex. ENOTS. B'HAM 33143

CONTRACTS

an order for an 11-roll backed-up roller leveller for dealing with hot steel plates up to 1 in. thick by 10 ft 6 in. wide. In addition, a further order has been received from the Consett Iron Co. Ltd. for a second 9-roll backed-up leveller capable of handling hot plates up to 1½ in. thick by 10 ft 6 in. wide. The total value of contracts received recently for plate levellers for the steel industry amounts to approximately £550,000.

* * *

The General Electric Co. Ltd., of England are engaged on an order from the British Transport Commission for the electrical equipment for 23 high-speed a.c. multiple-unit electric trains. Designed for a maximum service speed of 90 mph, these trains, of which 15 are four-car and 8 are two-car types, will run on inter-city services on the Eastern Region between Liverpool Street and Clacton or Walton. This order, valued at over £580,000, is the first ever placed in the U.K. for motor-coach equipment to operate at such a high speed. The equipment, which may be regarded as the prototype for this kind of unit, includes transformers, silicon rectifiers, traction motors, control gear, and cables.

* * *

The South of Scotland Electricity Board has placed an order, valued at approximately £1,250,000, with Scottish Cables Ltd., a member of the BICC Group, covering the supply and delivery during 1961 of a wide range of paper- and plastic-insulated underground cables, to be utilized for the distribution of electricity throughout the S.S.E.B. areas.

* * *

The English Electric Co. Ltd. has received a repeat order for a 200-MW steam turbo-alternator for the Electricity Supply Commission of the New South Wales power station at Vales Point, situated 70 miles north of Sidney on the southern shore of Lake MacQuarie. The new turbo-alternator embodies design features which have been evolved and developed in the company's research laboratories, the contract, with the auxiliary plant manufactured in Australia, being valued at £A2,250,000. The turbo-alternator will be installed next to the first two 200-MW sets, also to be supplied by English Electric, in accordance with a contract valued at £A4,750,000 and the station, when completed, will be the largest in the southern hemisphere.

* * *

Bowaters Engineering & Development, Inc., of Calhoun, Tennessee, has ordered from AEI (Canada) Ltd., seven single-reduction gearboxes and spares, valued at £70,000, for wood-pulp grinders for use in a wood-pulp mill of the Tasman Pulp and Paper Co. Ltd., of Kawerau, New Zealand. Of these gearboxes, each of which will transmit 6325 hp, six will have a speed reduction of 1000/250 rpm, and the seventh 1000/300 rpm, the reductions of the replacement rotating parts being from 1000 to 375, 333, and 250 rpm respectively. All these gearboxes will be manufactured at Rugby by the AEI Heavy Plant Division.

can you afford to stand still ?

. . . are you still losing time and money by repairing screw threads in the old-fashioned way?
Heli-Coil Screw Thread Repair Kits enable you to replace weak or stripped threads in minutes, at a cost almost too small to estimate!
Simply drill, tap and install a Heli-Coil Insert to produce a conventional thread many times stronger than an unprotected thread. It will outlast the rest of the part!
Although the cost of Heli-Coil Inserts is negligible, they are capable of making items serviceable when the metal is too worn to withstand ordinary screw thread repair. Years of use can now be obtained from parts that would otherwise have to be scrapped. The cost of complete replacements is saved and the inconvenience of delays. Three standard types of Heli-Coil Repair Kits are available, plus Special Purpose Kits "tailored" for particular products. Heli-Coil Inserts are made with either English, American or Metric Threads.

HELI-COIL* screw thread repair kits

* HELI-COIL is a registered trade mark

MAIL THIS COUPON FOR FULL INFORMATION ABOUT HELI-COIL

PLEASE FORWARD ILLUSTRATED LITERATURE ON HELI-COIL SCREW THREAD REPAIR KITS TO:

NAME .....

COMPANY .....

ADDRESS .....

.....

ARMSTRONG PATENTS COMPANY LIMITED
Eastgate Beverley, Yorkshire. *Tel. Beverley* 82212 (6 lines)
And at Melbourne, Australia. Montreal and Toronto, Canada.
48/K.9

DOWTY

PRECISION MOULDINGS and GASKETS

in Natural, Synthetic and Silicone Rubbers. Bonded, P.T.F.E. and Nylon Components.

DOWTY SEALS LIMITED · ASHCHURCH · GLOS.

Member of the Dowty Group

Telephone: Tewkesbury 2271.

PERSONAL

Mr. A. J. Scamp has been appointed a director of F. Perkins Ltd., of Peterborough, and will be associated with the group's personnel and industrial-relations activities.

* * *

It is announced by the Consolidated Pneumatic Tool Co. Ltd., of London, W.6, that **Mr. A. R. Jackson** has been appointed to the board of the company. Mr. Jackson is general manager of the company's Australian branch, and will continue to be in charge of operations in that country.

* * *

Mr. S. K. Wheatley has been appointed a director of the Sheffield Wire Rope Co. Ltd., a member of the Firth Cleveland Group.

* * *

Mr. Claud Laurence has resigned from the board of Laurence, Scott & Electromotors Ltd. after 37 years of service. His son, **Mr. J. A. Laurence,** has been appointed to the vacancy thus created.

* * *

Mr. N. J. Fuller has been appointed assistant sales manager of Goodyear Pumps Ltd., of London, W.1, a company in the Holman Group. **Mr. J. C. Reid** has been appointed representative of the company in Scotland.

* * *

It is announced by The British Internal Combustion Engine Research Association that **Mr. J. G. Dawson, B.Sc., M.I.Mech.E.,** has succeeded **Mr. V. H. Hopkins** as Chairman of Council, while **Mr. S. J. Wood** has been elected Vice-Chairman.

* * *

Mr. E. S. Hall, M.I.E.E., M.B.K.S., a director of AEI Sound Equipment Ltd., and divisional assistant chief engineer of the AEI Electronic Apparatus Division, of New Parks, Leicester, has taken office as chairman of the Rugby sub-centre of the Institution of Electrical Engineers.

* * *

Hamworthy Engineering Ltd., of Poole, Dorset, announce that **Mr. R. J. Gates** has joined the company as director and executive assistant to the managing director.

* * *

It is announced by The United Steel Companies Ltd., of Sheffield, that, following the appointment by Tube Investments Ltd. of **Mr. G. E. D. Halahan,** at present director and general works manager of Steel, Peech and Tozer, as director and general manager of the Round Oak Steelworks Ltd., from December 1, 1960, they have appointed **Mr. H. Darnell,** director and general works manager of the Workington Iron and Steel Company, as

HARD ANODISED ALUMINIUM OUT-WEARS STEEL

a process you must investigate!

A & A HARD ANODISING produces a wear resistance coating on aluminium and alloys, comparable to the surface of hard tool steel. Comparative tests with cyanide-case hardened steel proves that HARD ANODISING has approximately *TWICE the wear resistance.*
This A & A process is also a heat insulator and will absorb and retain oil when used on cylinders and pistons.

Hard Anodising is used for Bearings: Brake and Clutch Discs: Cams: Computer Gears: Fans: Timing Gears: Nozzles: Pistons: Pump Housings—Fuel/Oil: Spray Guns: Surgical Splint Valves: Ticket Machine Gears: Hydraulic Jack—Screw Threads, etc., etc.

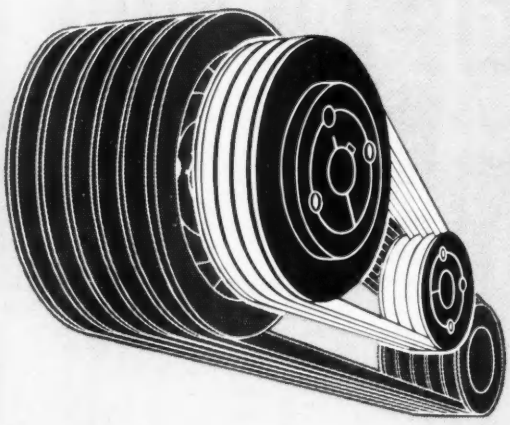
Where hardness and lightness are vital A & A HARD ANODISED aluminium provides the answer. For details and production data for your own work, consult . . .

ALUMILITE & ALZAC LTD.

PRIORY WORKS, DEPT. N, STATION RD., LONDON, S.W.19
Telephone: LIBerty 7641

MIDLANDS: 20/21 MERIDEN STREET, BIRMINGHAM, 5
Telephone: MIDLAND 7426

V-Belt Drive and WEDGE-Belt Drive for the same job



Fenner SpacesaVer Wedge-Belt Drives are

SLIMMER, LIGHTER, SHORTER, CHEAPER

- Width and weight now reduced by a half, and cost by at least a fifth, without loss of strength or durability.
- Modern materials and a new belt section give a much greater power capacity. SpacesaVer Wedge-Belts make full use of the strength and flexibility of Terylene cords. These are bonded to a synthetic rubber which keeps them exactly where they can do most work with least stress to themselves. This rubber provides heat and oil resistance and adequate electrical conductivity at no extra charge. New pulley designs take full advantage of modern casting methods to give stronger, yet lighter pulleys. All have Taper-Lock quick and easy fixing facilities.
- Two Wedge-Belt sections, $\frac{3}{8}$" (Alpha) and $\frac{5}{8}$" (Beta) cover all normal drives up to 200 horse-power. Belt lengths and pulley diameters are based on International Standardisation principles. Your complete drive design can be selected from a single line reading in the SpacesaVer catalogue 135/20. Send for it now.

THE GREATEST ADVANCE IN DRIVE DESIGN FOR 30 YEARS

HERE IS THE PROOF

DRIVE		MOTOR PULLEY DIAM.	DRIVEN PULLEY DIAM.	FACE WIDTH	V-BELTS AND WEDGE-BELTS USED	CENTRE DISTANCE	DRIVE LIST PRICE	DRIVE WEIGHT LB.
5 H.P.	V-Belt	$3\frac{3}{4}$	$6\frac{3}{8}$	$3\frac{1}{4}$	5—A29	7·5	£6 · 8 · 7	16·7
	Wedge-Belt	3·15	5·60	$1\frac{1}{2}$	3 Alpha 280	7·1	£5 · 3 · 8	10·6
	SAVING	**16%**	**12%**	**54%**	—	**5%**	**19%**	**36%**
25 H.P.	V-Belt	$6\frac{1}{2}$	$12\frac{1}{2}$	$5\frac{7}{32}$	6—B65	18·7	£17 · 0 · 7	66·8
	Wedge-Belt	5·3	10·6	$2\frac{23}{32}$	6 Alpha 560	15·3	£11 · 11 · 6	36·2
	SAVING	**18%**	**15%**	**48%**	—	**18%**	**32%**	**45%**

SpacesaVer **WEDGE-BELT DRIVES**

MADE ONLY BY

Fenner

J. H. FENNER & CO. LTD. HULL

Catalogue 135/20 details drives up to 200 h.p. Send for it NOW!

NAME AND POSITION .....

FIRM'S ADDRESS .....

THE LARGEST MAKERS OF V-BELT DRIVES IN THE COMMONWEALTH

PERSONAL

director and general works manager of Steel, Peech and Tozer. **Mr. N. D. Macdonald,** at present works manager (iron) of the Appleby-Frodingham Steel Company, is to be general works manager of the Workington Iron and Steel Company.

* * *

Mr. R. Miles, who recently retired as chairman of Head-Wrightson & Co. Ltd., has been appointed a director and chairman of Joy-Sullivan Ltd., of Greenock, Scotland.

* * *

It is announced that **Mr. F. C. Leigh** has been appointed general sales manager of the Plastics Division of the Telegraph Construction and Maintenance Co. Ltd., of Orpington Kent.

* * *

Mr. P. B. Ades, M.S.M.A., and **Mr. B. J. S. Tetlow, A.M.I.W.M.,** have been appointed to the board of Airmec Ltd., of High Wycombe, Bucks, as sales director and works director respectively.

* * *

Following their move to new and larger office and warehouse premises at Windsor Works, Venn Street, Clapham, London, S.W.4, Foster Brothers (London) Ltd., the London subsidiary of Foster Brothers Ltd., of Wednesbury, announce that, owing to advancing years, **Mr. A. T. Ayers** is shortly retiring from the board, his place being taken by **Mr. J. S. Derek Ayers,** who is the son of the managing director, **Mr. J. A. Ayers.** It is also announced that **Mr. J. H. Watson** has joined the sales side of the company.

* * *

Mr. A. S. Gill has retired from the board of George Cohen Sons and Co. Ltd., on attaining the age of 65, and will practise as an industrial consultant.

* * *

Mr. J. F. Parker (chairman), **Mr. G. St. J. Strutt, C.B.E.,** and **Mr. E. S. Parker** have retired from the board of British Rolling Mills Ltd. Mr. J. F. Parker was a founder director of the company, while Mr. Strutt served as a director for 40 years and Mr. E. S. Parker has been connected with the company for nearly 50 years. **Mr. R. Ll. Lloyd** has been appointed chairman.

* * *

Mr. H. C. CLEMENTS

It is with deep regret that we announce the death of Mr. H. C. Clements as the result of a motor accident. Mr. Clements was associated with the Engineering Division of W. Canning & Co. Ltd., of Birmingham 18, for 40 years and was a member of the board of directors until prolonged ill health caused his resignation in November 1959.

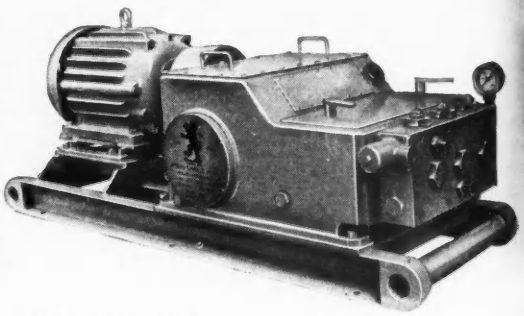
NEW

worm drive hydraulic pump

incorporating many interesting features

This pump is specifically designed as a mining hydraulic pump and incorporates many features based on our long experience of mining duties. In particular we would mention—

- *COMPACT DESIGN OF MINIMUM DIMENSIONS*
- *ALL STEEL CONSTRUCTION*
- *LOW PLUNGER SPEEDS*
- *MINIMUM WEIGHT FOR EASE OF HANDLING*
- *EASE OF OPERATION*
- *MINIMUM MAINTENANCE*
- *EASE OF DISMANTLING*



The unit is suitable for operation with water, water/soluble oil mixture and hydraulic oil.

Write for literature.

Joseph Evans

JOSEPH EVANS & SONS (WOLVERHAMPTON) LTD.
Nine Elms Iron Works, Reading, Berks.
Tel: Reading 67182/4

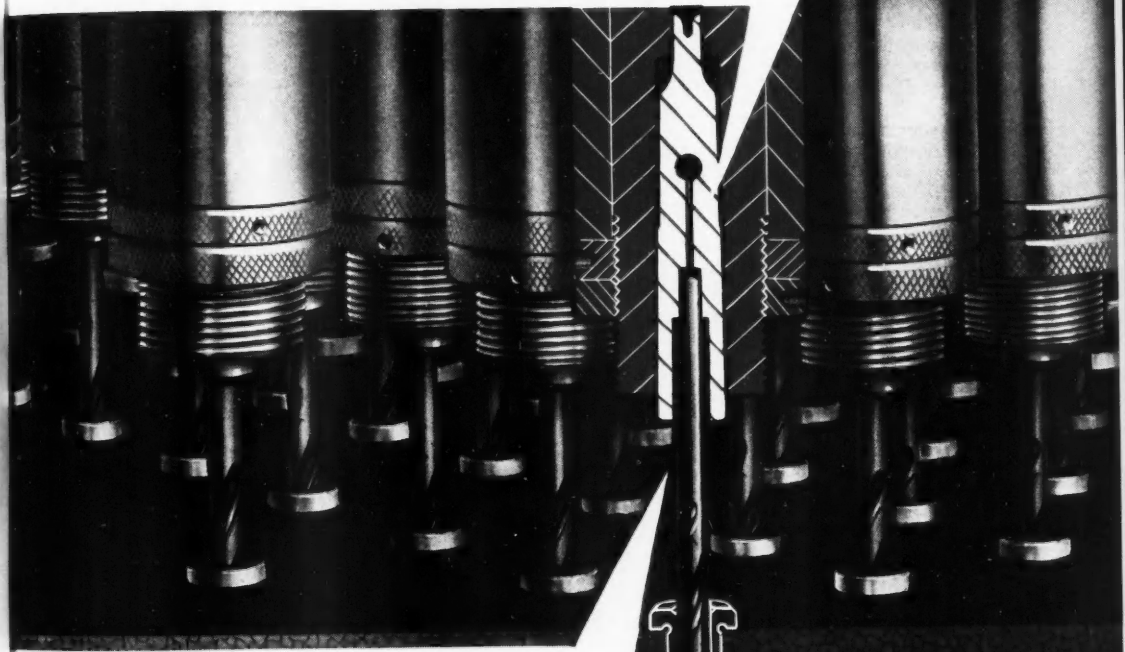
London Offices: Pulsometer House, 20/26 Lamb's Conduit Street, London, W.C.1. Tel: HOLborn 1402

Branch Offices at Glasgow, Manchester, Birmingham, Cardiff, Newcastle, Derby

ANOTHER

DORMER

ECONOMY



r repetitive drilling of any particular size of hole, where a taper drive required, considerable savings can be effected by using a DORMER nversion Sleeve and straight shank drills with tang. One sleeve tlasts numerous drills—replacement straight shank jobber drills are eaper than those with taper shanks.

ditionally this drive permits drilling to much closer centres than with e conventional straight shank drill chucks—more holes can be drilled ultaneously.

comprehensive range of DORMER Drills are available with tanged raight shanks.

scriptive brochure available.

E SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED
EFFIELD ENGLAND

RMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

CONVERSION SLEEVES AND TANGED STRAIGHT SHANK DRILLS

NEWS ROUND-UP

The Machine-Tool Industry Research Association

A new research association, specifically intended to serve the British machine-tool industry, is now in process of formation. Sponsored by the Machine-Tool Trades Association, who took a leading part in the establishment of the Production Engineering Research Association nearly 20 years ago, the new research association will administer funds contributed by the industry for the purpose of co-ordinating, accelerating, and initiating research projects for the benefit of machine-tool design and production. For this purpose, all appropriate and available existing research facilities throughout the country will be used. By this means, quicker results from a wider range of research projects will become available to the industry than would be the case if the Machine-Tool Industry Research Association waited for the erection and equipment of their own laboratories.

An early and useful effect will be the acceleration of work on machine-tool projects at present proceeding at research associations, universities, government establishments, and privately owned laboratories. New work will be let out by contract to such establishments under the supervision of a director of research of the highest qualifications, who will be appointed at an early date. Approximately 100 manufacturers of machine tools and in closely allied industries have undertaken the financing of the new research association for a minimum of five years. It is the intention to apply for grant aid to the Industrial Grants Committee of the Department of Scientific and Industrial Research.

Conference on Irreversibility and Statistical Mechanics

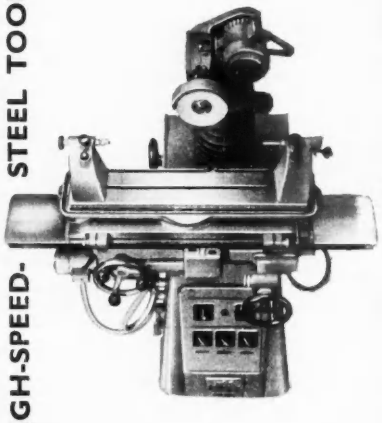
The Institute of Physics and The Physical Society announce that they are arranging a conference on statistical mechanics (with special reference to irreversibility), to be held at Queen Mary College, London, on December 19 and 20, 1960. A full programme has already been arranged, the topics including the general theory of irreversibility, random processes, liquids (theory and experiment), and irreversibility in gases and in plasma.

Further information can be obtained from the Secretary, The Institute of Physics and The Physical Society, 47 Belgrave Square, London, S.W.1.

Proposed Amalgamation of the Institutions of Civil Engineers and Municipal Engineers

The terms of the amalgamation of the Institution of Civil Engineers and the Institution of Municipal Engineers have now been approved by the Councils of the two Institutions and have been embodied in a formal agreement. As a result, the Institution of Civil Engineers has sent a voting paper and full details of the agreement, together with a letter from its President, Sir Herbert Manzoni, to some 17,000 corporate members in all parts of the world. The Institution of Municipal Engineers has similarly sent a voting paper to its 6,000 corporate members.

This is a big step in the unification of the engineering profession, involving as it does two of the eldest engineer-



MILLING CUTTERS · THREAD-MILLING CUTTERS · HIGH-SPEED-STEEL TOOLS

For all precision tool grinding operations, wet or dry, ask us for details of

THE UNIVERSAL TOOL GRINDER

LIVET 4 P

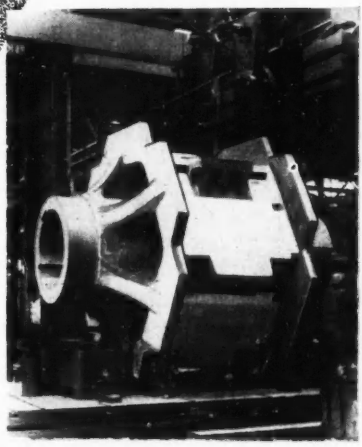
developed by specialist tool designers

LIVET

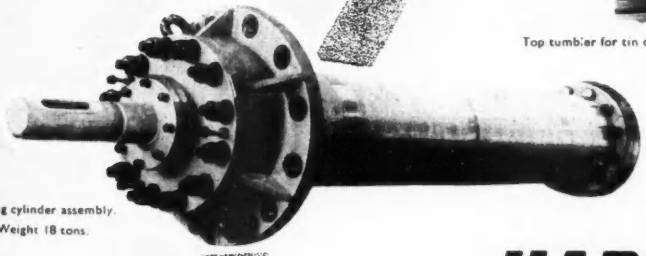
30 rue RAMUS, PARIS, 20. ROQ 70-14

THINK OF CASTINGS FIRST

Best quality steel castings have many applications which offer certain economical advantages over other production methods. Before finalising your requirements **THINK OF CASTINGS FIRST** and consult Hadfields . . . . . a name for Steels in **CARBON—LOW ALLOY —STAINLESS—MANGANESE— WEAR RESISTING—HEAT RESISTING STEELS.**



Top tumbler for tin dredging. Weight 17½ tons.



Tilting cylinder assembly. Weight 18 tons.

HADFIELDS
SHEFFIELD

HADFIELDS LTD., EAST HECLA WORKS SHEFFIELD ENGLAND

NEWS ROUND-UP

ing Societies in this country. The Institution of Civil Engineers is, in fact, the oldest in the world, being founded in 1818. The Institution of Municipal Engineers was founded in 1873 and is a society of comparable status with that of the Institution of Civil Engineers in a slightly narrower field. As Sir Herbert Manzoni points out, the policies of the two Institutions have been drawing closer together during the past four years. In 1956, an important step was taken when the Institution of Municipal Engineers agreed to participate in the joint Part I examination of the Engineering Institutions. There were then discussions on other points of interest and "such a considerable degree of harmony became apparent throughout these discussions, that amalgamation was openly talked of in the light of the ultimate policy of re-unification of the whole profession", and a committee was set up over twelve months ago to draw up terms which would commend themselves to corporate members of both Institutions.

New English Electric Transformer Works

The English Electric Co. Ltd. have transferred the development and manufacture of transformers of from 1·5 to 400 MVA and more, together with the associated test work, to a new works at Stafford, the building covering an area of 245,000 sq ft, with six parallel bays, each 580 ft long, the largest of which is 85 ft wide. Specifically laid out for the purpose of producing and testing transformers, the works embody two main features, the first being flow-line production from raw materials to final test, with a minimum movement of components or a completed transformer, and the second the provision of sufficient head-room and lifting gear to enable the very large 500- or 600-MVA transformers envisaged for the future to be "leap-frogged" down the production line by hoisting them up and moving them by travelling cranes.

The main bay is designed for two 200-ton cranes which can be used together to move up to 400 tons through a 60-foot lift. Attention has also been given in the lay-out to the problem of moving large loads. With the increasing sizes of transformers, the physical dimensions of the equipment after it has been divided into components for shipment still create problems in transportation in the U.K. and overseas. For this reason, a wide gangway runs between the final assembly bay and the test area, so that components can be loaded directly onto a transporter.

In the test area is installed what is believed to be the most powerful impulse generator in the word, capable of producing 4·8 MV with a 346-kWsec energy rating. Complete tests, including a full-load heat run, can already be made with the present plant on transformers up to 600 MVA at 50 cps, or substantially larger transformers at 60 cps. An extremely versatile range of testing transformers is installed to permit the selection of any voltage between 11 and 80 kV in steps of approximately 1 kV, thereby allowing optimum use of the test-plant capacity.

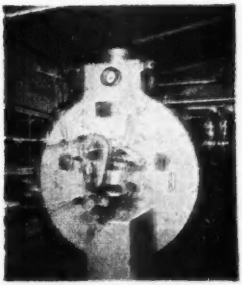
The major part of the test plant is installed in a separate machine hall, which is air-conditioned and temperature-controlled. Effective separation of the rotating machinery from the outside test area becomes increasingly important when a subdued ambient noise level is necessary during transformer sound-level tests. Careful attention has been paid to extreme accuracy of instrumentation, particularly in the case of equipment used at power factors down to 0·05, a value which is common enough in the measurement of transformer copper loss. At this power factor the instrumentation is accurate to within 0·5%. The current and voltage transformers associated with these instruments are permanently installed in the test bus system and have been calibrated *in situ* at low power factors.

Testing carried out at shop-floor level is marshalled from control galleries overlooking the test area. A radio link between the various members of a team ensures that all tests are completed without unnecessary delay. Eight transformers can be tested simultaneously with the facilities available.

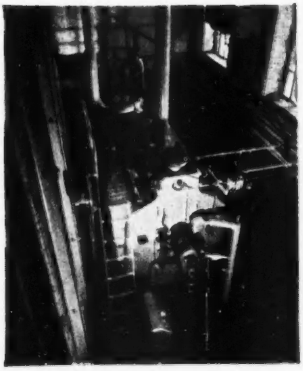
Specialized Plant for the Protective Coating of Heavy Equipment

Based on specialized plant recently installed at Norton Street, Miles Platting, Manchester, by West's-Loyne Ltd., a new industrial service is designed to cater for the application of a comprehensive range of anti-corrosion and protective coatings to heavy equipment up to 5 tons in weight. This is the first time that such facilities have been made available under conditions where close control can be maintained throughout the process, i.e., from the stages of initial preparation to final curing.

The plant includes one of the largest fully automatic shot-blasting cabinets installed in Britain for this kind of work as well as a large gas-fired oven for the sintering and stoving of coatings or for the heat treatment of metals. The installation is complete with up-to-date preparation and coating equipment and the necessary cranes for the moving of large items while under treatment. The gas-fired oven is 30 ft long, 12 ft wide, and 10 ft high, and is designed for sintering P.T.F.E. and P.C.T.F.E. and for stoving high-bake epoxy, phenolic, and silicone coatings. A temperature of 450°C can be attained when needed for the heat treatment of metal before P.T.F.E. coating. Provision is also made for curing coatings by hot air and infra-red heaters. Other facilities available include the shot-blasting of very large vessels in the open with mineral grit, and, if required, work can be prepared by flame-cleaning and power wire-brushing.



Wright, Layman and Umney Ltd.

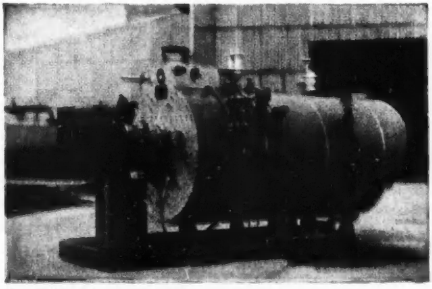


Esso Refinery Manchester

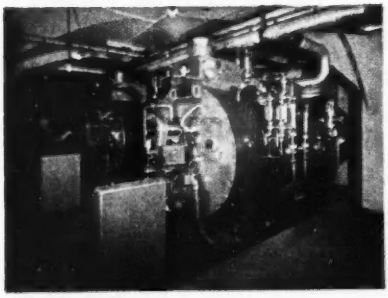
Jacqmar Mills Burnley

This is why they choose Multipac

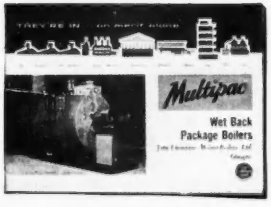
Multipac, backed by over 100 years experience, has many special features and characteristics which, in combination, have led to more and more steam users choosing this boiler.
Its dished-ended wet-back combustion chamber eliminates refractory linings and brickwork. Rapid circulation is obtained because of the 3-pass combustion gas system and its wet-back combustion chamber, giving 82% efficiency. Its quietness cannot be overstressed as a special characteristic; this is why many hospitals use Multipac. Cleaning of the firetubes is only required at very infrequent intervals and easy accessibility is provided. The Multipac is British designed and Clyde built and requires very little floor space, a flat concrete floor is all that is required as a foundation. The standard Multipac is oil fired but another model the Multipac SF is designed for coal firing.



Complete steam tested ready for despatch



Ashridge College Kent



Please write for new brochure on Multipac, or better still why not come and see one at our works.

JOHN THOMPSON (WILSON BOILERS) LTD.
Lilybank Works · London Rd · Glasgow E.1

JOHN THOMPSON (WILSON BOILERS) LIMITED · JOHN THOMPSON GROUP

LETTERS TO THE EDITOR

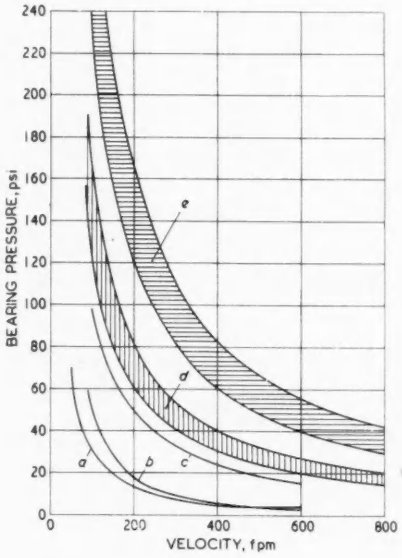
DESIGN DATA FOR PLASTIC BEARING MATERIALS

Sir,

In your issue for July 1960, you published an abstract of an American article on "Design Data for Plastic Bearing Materials", by L. H. Gillespie and G. S. Hudson.

I was very sorry to see space given to information which was out-of-date generally as far as design, research, and development are concerned, and which, for the reinforced-P.T.F.E. materials described, was practically misleading, since the design data offered were much more limited than they were for the more advanced British products that you yourselves have already published, e.g., in your issue for April 1958 under the title of "Properties and Applications of 'DU' Unlubricated P.T.F.E.-Type Bearings".

In addition, it is well known that data on dry bearing performance are virtually useless to the designer unless the minimum life for this performance is also given—a consideration which is absent from the table and curves of *PV* data in the article.



To illustrate the points I am making, I am enclosing a graph of bearing pressure as a function of velocity (based on the *PV*-values in the table in your article) for the acetal, nylon, and reinforced-T.F.E. resins described (curves *a*, *b*, and *c* respectively), as compared with Glacier "DU" reinforced-T.F.E. fluorocarbon materials under unidirectional-load conditions with a mild-steel shaft (curve *d*), and under fixed-load conditions with an oscillating hardened shaft (curve *e*), the ranges shown for the "DU" material being for a life of 1,000 to 10,000 hours.

The subject of plastic bearings is one of increasing importance, interest, and application, and one in which a British company leads the world, in competition with American products in the U.S.A., as well as elsewhere, and a British technical digest should be doubly careful, therefore, not to give the impression that data from an American source are beyond reproach.

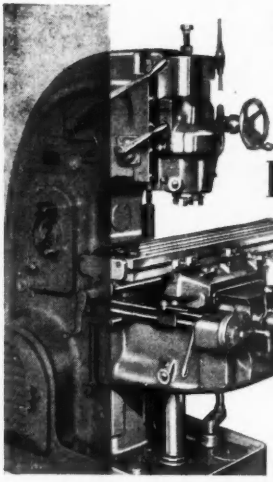
Yours faithfully,

A. D. NEWMAN,
Engineering Research Manager,
The Glacier Metal Company, Limited,
Alperton, Wembley, Middlesex.

We thank Mr. Newman for providing us with these interesting details of the performance of "DU" reinforced-T.F.E. fluorocarbon materials compared with those of the materials described in the American article. There can be no doubt, as Mr. Newman says, that Britain leads the world in the field of plastic bearings; at the same time, however, we feel he is a little unfair in his criticism that, because of this superiority, a British journal should not give the impression that data from an Amercian source are beyond reproach. By the same token, this criticism implies that the article should never have been published at all in our journal.

On both these counts, we fear we must disagree. As a matter of fact, our publication of this article in no way suggests that American developments in this field (or, for that matter, any other) are necessarily the most advanced in the world, but that they are indicative merely of the presumably latest stage of developments in the U.S.A., and not on an international basis. Thus, while it is true that most of our articles are selected on the merits of the information they present on an international basis, others are selected because of their topicality, even if the developments they report may lag behind those of other countries. In such cases, the publication in our journal of articles from any particular country therefore serves to pinpoint the latest developments in that country, and we believe that details of these developments must be of interest to readers in other countries.

That this belief is well founded is evidenced by the increasing number of cover-to-cover translations of Russian technical journals, even though it is known in advance that many of the developments reported therein are neither particularly original nor particularly new. In such cases, if Mr. Newman's criticism were valid, most of the contents of Russian technical journals would not be translated at all, and doubtless much interesting information would be denied to potential readers, particularly with regard to comparing developments in that country with those in their own.—*Editor.*



SAVED!
by
BROCKHOUSE

MACHINE TOOL REBUILDING SERVICE

Why not consult us about that one-time useful machine tool which is now standing idle? We have a comprehensive machine tool rebuilding service available for LATHES, AUTOMATICS, MILLERS, SHAPERS, PRESSES AND DIE CASTING MACHINES up to 8 ton weight (approx.).

Send for a descriptive leaflet:

J. BROCKHOUSE & Co. Ltd.

Machine Tool Division · ELMS WORKS · WOLVERHAMPTON

Tel. 23801

DOWNWARDS PRESSURE

SIDEWAYS PRESSURE

provide a really rigid grip

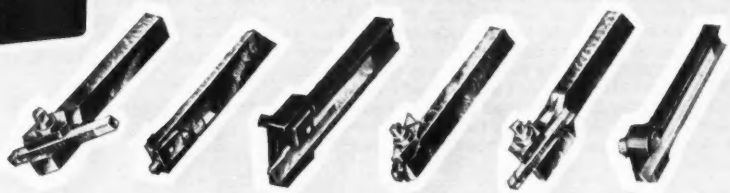
. . . . With Eclipse Tool Bit Holders there can be no tool bit chatter or loss of rigidity. The patent clamp grips along its full length, exerting pressure both downwards and sideways, to hold the tool absolutely rigidly. Like all Eclipse tools, Eclipse tool holders are carefully machined and finished. The groove which holds the tool provides a really flat base and, being open, can be kept clean and free from swarf. The shank of the tool is accurately machined so that the holder can be firmly and accurately held on the tool rest.

Right, left and straight holders—for English type lathes $\frac{3}{16}$" to $\frac{1}{2}$", $\frac{5}{8}$" to $\frac{3}{4}$".

Straight holders—for American type tool posts $\frac{1}{4}$" to $\frac{5}{16}$", $\frac{3}{8}$" to $\frac{1}{2}$", $\frac{5}{8}$" to $\frac{3}{4}$", $\frac{7}{8}$" to $1\frac{1}{4}$".

Cutting off tool holders—$\frac{5}{16}$", $\frac{1}{2}$" to $\frac{5}{8}$" width, $\frac{11}{16}$" to $\frac{7}{8}$" width, 1" to $1\frac{1}{4}$" width.

Eclipse



ECLIPSE TOOL BITS IN ECLIPSE TOOL HOLDERS ARE THE FINEST CUTTING COMBINATION

'Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

U.T.H.3.

NEW TECHNICAL BOOKS

Introduction to the Gas Turbine. 2nd Edition, 1960. By D. G. Shepherd. 310 pp., 174 illustrations. Publishers: Constable & Company Ltd., 10 & 12 Orange Street, London, W.C.2. Price: 45/–.

Although this excellent book is, strictly speaking, a second edition, it is in fact a virtually new textbook, inasmuch as it has been completely rewritten and adopts a more basic approach to the subject than the first edition, by imparting more principle and less detail. In this way, based on the experience of the author, who is Professor of Mechanical Engineering at Cornell University, during the years intervening since the publication of the first edition in 1949, it was felt that this new approach would lead to a better understanding of the subject and would enable it to be viewed in a wider perspective.

In this new edition, it is assumed that the reader has a knowledge of elementary thermodynamics and fluid flow. Cycle analysis is dealt with more fully than before for various reasons and includes a number of demonstrations of simple analytical methods, to encourage readers to adopt similar methods to discover performance trends in those problems they may encounter. In addition, the chapters on components are couched in a more unified fashion than formerly, imparting sufficient knowledge of the main elements to enable an assessment and understanding of performance to be made, rather than to impart design methods in detail. Also included is a brief review of existing and possible future applications, together with an assessment of the potentialities of gas turbines. In short, Professor Shepherd's modified approach to his subject is eminently successful, and the result is an authoritative and admirably written textbook of undeniable value to students and others in this field.

Machine Drawing and Design. 7th edition, 1960. By W. Abbott, C.M.G., O.B.E., Ph.D., B.Sc., M.I.Mech.E. 281 pages. Publishers: Blackie & Son Ltd., 17 Stanhope Street, Glasgow, C.4. Price: 21/–.

Originally produced in 1930 and now largely rewritten since the publication of the 6th edition in 1954, this excellent and deservedly popular book is intended to provide an intermediate course in Machine Drawing and Design for students of mechanical engineering. At the same time, however, the inclusion of representative designs and of standard data also renders the book of value to draughtsmen and others engaged in engineering practice.

It has been assumed that the mere copying of views of engineering drawings is unprofitable and that students should acquire, concurrently with drawing practice, a knowledge of the function of the articles they are depicting and of the factors involved in settling their proportions. For this reason, most of the drawings included in the book are pictorial and the text provides an introduction to the design of the more common details of machinery. It is also assumed that the allied subjects of Mechanics and Strength of Materials are being studied concurrently, so that the various formulae used will not be unfamiliar. Insofar as the designs included in the book are concerned, these have been selected as being representative of successful practice.

Modern Workshop Technology (Part II). 2nd edition, 1960. Edited by H. Wright Baker, D.Sc., M.I.Mech.E. 658 pp., 428 illustrations. Publishers: Cleaver-Hume Press Ltd., 31 Wright's Lane, Kensington, London, W.8. Price: 55/–.

Containing a number of contributions from recognized experts in their own particular field, this second edition of Part II of Modern Workshop Technology, dealing with machine tools and manufacturing processes, has been largely rewritten and introduces several new topics, resulting in a marked increase in the length of the book. Thus, the book now opens with a chapter on the general principles common to all machine tools and is followed by a discussion of the theory of cutting. In this way, the remaining sections are devoted entirely to specific machine tools and specific techniques, and space is available for a more extended treatment of important general aspects such as surface technology, lubrication, heat treatment, production planning, safety, and human relations.

The "Advance" Science Masters Handbook. Compiled by Ivan L. Muter, B.Sc., A.M.I.E.E., A.Inst.P. 124 pp., 147 illustrations. Published by Advance Components Ltd., Roebuck Road, Hainault, Ilford, Essex. Price: 12/6.

Stemming from the knowledge that many science masters in "modern" schools have experienced difficulties in demonstrating the theory taught during their lectures, this excellent little book has been specially prepared to aid science masters in the task of instructing budding electronics engineers. To this end, the book is arranged in two parts, the first devoted to theory and reference material, and the second to laboratory experiments and demonstrations with a minimum of test apparatus, covering general electronics theory and sound and wave motion, together with relevant facts and figures.

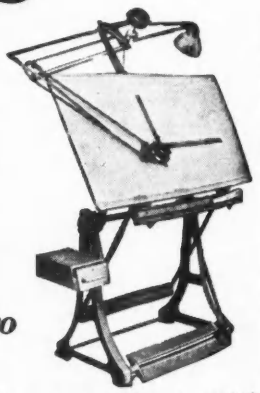
The book is beautifully produced and generously illustrated, and each of the 47 experiments included has been carefully devised to suit the particular requirements of school laboratories. Although, of course, the series cannot be complete, the nature of the demonstrations given will undoubtedly suggest other applications, and much time-consuming verbal and blackboard instruction will inevitably be reduced.

The last word in Drawing Office Efficiency

ISIS

DRAFTING MACHINES & DRAWING TABLES

Isis Drafting Machines are now fitted with improved Protractor Heads. The special features are fully explained in our ISIS folder which will be gladly sent on request. The ISIS Drawing Tables are in complete balance at any height or inclination of the board.



We are distributors of ARISTO *slide rules of precision*

RIEFLER *Drawing Instruments of quality*

Illustration shows ISIS drawing table fitted with ISIS drafting machine

J. W. SMITH (COVENTRY) LTD

DRAWING OFFICE SUPPLIES AND EQUIPMENT

36 & 41 QUEENS ROAD, COVENTRY

Telegrams: 'ISIS' COVENTRY
Telephone: Coventry 26941/2

Fusion

OF ELEMENTS IS THE BASIS OF STEEL—

FUSION OF KNOWLEDGE IS THE BASIS OF

FABRICATED STEEL

To-day's demand for high quality steel fabrication has imposed a heavy load on the talent and production available. Lomount's policy is to eliminate frustration by delivering to a realistic date or declining to attempt the impossible.

Standards of workmanship and price are compatible with popular demand, and courteous interest is the keynote of their dealings.

An inquiry for one off or many will bring rapid and earnest response.

Try it some time . . . .

The firm with a flair for fabrication

LOMOUNT

VEHICLES & ENGINEERING LIMITED

Sackville House, 40 Piccadilly, London, W.1.
REG 2112/6
Works: COLNBROOK, SLOUGH, BUCKS.
Colnbrook 2676

LATEST INDUSTRIAL LITERATURE

1. Transformers

An illustrated 24-page catalogue contains information on the development, manufacture, and application of transformers and gives details of core construction and assembly, coil winding, and fabrication, inspection, and testing of transformers. Particulars are also included of rural transformers, small-transformer cores, and dry-type, oil-filled, and resin-cast transformers for electronic applications.

2. Diaphragm Pumps

Designed in hand-operated and in motor-driven versions, a range of diaphragm pumps is described in an 8-page brochure. The pumps, which have delivery rates of 30 to 120 gph, or in larger units of 100 to 400 gph, are equally suitable for pumping corrosive and abrasive liquids and slurries, and are claimed to have extremely long service life.

3. Packings and Jointings

Information and guidance on the selection of packings and jointings is given in a well-produced 38-page catalogue. Sections are included on gland packings, sheet jointings, and leather hydraulic packings, and the materials used in the manufacture of packings and jointings are also dealt with. In addition, a comprehensive chart tabulates the effects of gases and liquids on these materials.

4. Rust Preventives

Intended for the protection of metal surfaces prior to fabrication and generally for temporary corrosion protection of metal, a special oil-type rust preventive is described in a 4-page brochure. The rust preventive can be applied by dipping, spraying, brushing, or swabbing, a thinner being available for applications where thinning is essential. Two additional brochures deal with an oily-film rust preventive for inter-process protection and with a rust-prevention varnish, which provides long-term protection against corrosion, abrasion, and scuffing and gives attractive high-gloss finish to metal parts.

5. Moulding Materials

Eminently suitable for the production of foundry patterns, matchplates, diesinking models, fibreglass mouldings, and prototype dies, a special moulding material is presented in a 6-page folder. The material is supplied in separate containers of powder and liquid, which, when mixed together in correct proportion and poured into moulds, set in a few hours to a marble-like hardness. The material has unique characteristics in reproducing exactly the details of any surface onto which it is poured, and is, therefore, particularly recommended for the production of moulds of intricate shapes.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 11.60
120 Wigmore Street, London, W.1.

Date .....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10 11 12

Name .....

Position .....

Company .....

Address .....

....

6. Muffles and Small Furnaces

Particulars are contained in an illustrated 30-page brochure of a wide range of laboratory muffles and small furnaces, such as horizontal rectangular muffles, high- and low-temperature melting furnaces, oval muffles, laboratory ovens, and tensometer and pyrometer testing furnaces. Details of a range of instruments and ancillary equipment are also given, including pyrometers and hand temperature-control panels.

7. Wedge-Belt Drives

Permitting the use of narrower grooves, smaller pulleys, and suitable for belt speeds of up to 6000 fpm, a range of wedge-belt drives is described in an 80-page catalogue. Information is presented on the methods of use, service conditions, and various design problems of the belt drives, and a great number of data sheets, selection charts, and tables of service factors are also incorporated.

8. Vacuum Induction and Resistor Furnaces

Suitable for melting and casting metals under high vacuum from crucibles ranging in capacity from one lb to one ton, a range of vacuum induction furnaces is dealt with in a 4-page folder. In these furnaces, all necessary ancillary equipment, such as moulds, thermocouples, etc., are contained together with the heating coil and crucible assembly in a steel work-chamber, which is evacuated by a high-speed pumping system. An additional 4-page folder contains details of vacuum resistor furnaces recommended for such applications as sintering, brazing, melting, and heat-treatment under vacuum.

9. Filtration and Deaeration Equipment

An illustrated 6-page folder contains particulars of a range of filtration equipment, including gravity, pressure, and diatomaceous filters. The filters are suitable for removing turbidity or suspended matter from raw water, which may be the result of lime, soda, or phosphate softening or other water-treatment processes. A supplementary 6-page leaflet describes a range of deaeration equipment, including spray-type, marine, and vacuum deaerators, supplied both to standard designs and to customers' specifications.

10. Electromagnetic Valves

The range of electromagnetic valves described in a 42-page catalogue includes single-way electromagnetic valves for air, water, and non-corrosive gases and three-way and four-way valves for compressed air or hydraulic fluids. The valves can be used for the automatic control of pneumatic, hydraulic, or electrical systems, while special valves are also available for continuous high-speed use, permitting up to 48,000 operations per hour.

11. Rubber Components

Details are given in a 4-page pamphlet of a range of rubber components manufactured by moulding or extrusion from natural, synthetic, and silicone rubbers, and available in a variety of shapes, such as grommets, O-rings, seals, diaphragms, bushes, and bonded parts. A supplementary 4-page folder contains details of special silicone-rubber components designed for various aircraft applications.

12. Extruded Steel Sections

Representing the latest advances in extrusion techniques, a range of extruded steel sections is presented in two 2-page leaflets. The extruded sections, which are produced in carbon, alloy, high-speed, special, and stainless steels, have identical physical properties with similar rolled sections, except their transverse tensile strength, which is increased by about 30%. The extrusions are supplied in the "as extruded" and descaled condition, but heat treatment and greasing can also be undertaken prior to delivery on request.

BHB pistons

for outstanding quality

Modern manufacturing techniques and first class workmanship enable BHB Pistons to obtain the high operative standard and consistent performance demanded by the Automobile Industry.

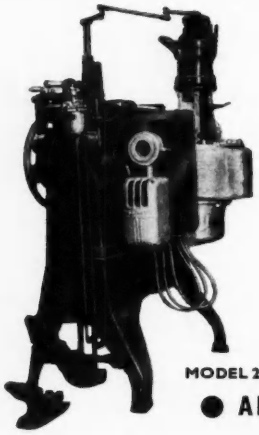
Manufactured by

automotive engineering limited

ONE OF THE SHEEPBRIDGE ENGINEERING GROUP

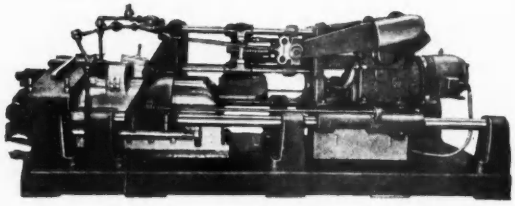
the green, twickenham, middlesex · telephone POPesgrove 2206/9 · telegrams 'MOTIF' twickenham

Coulthard Madison Kipp

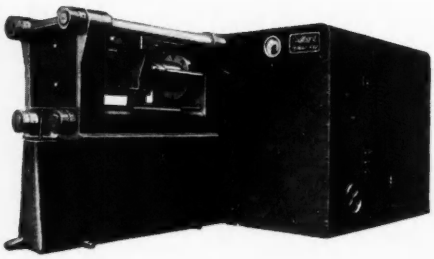


MODEL 215E

● ABSOLUTE ACCURACY

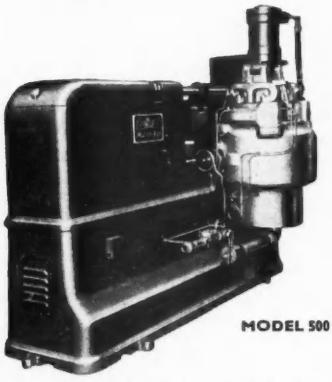


MODEL 4



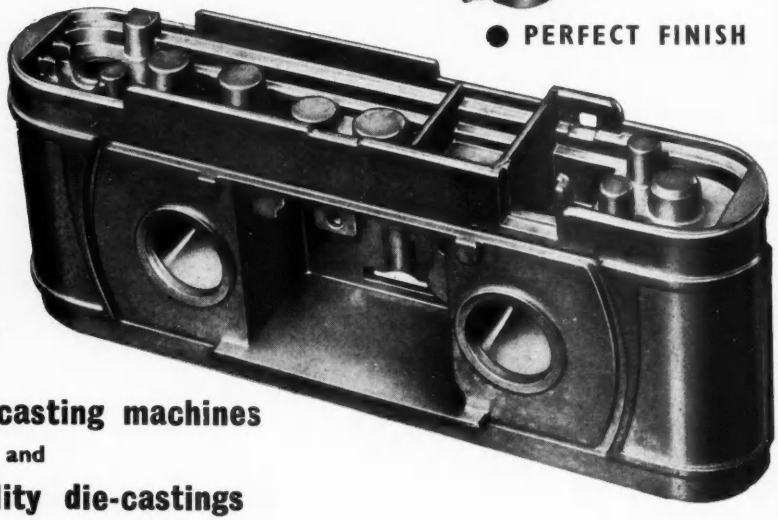
MODEL 450

● STRENGTH



MODEL 500

● PERFECT FINISH



hi-nich

pressure die-casting machines

and

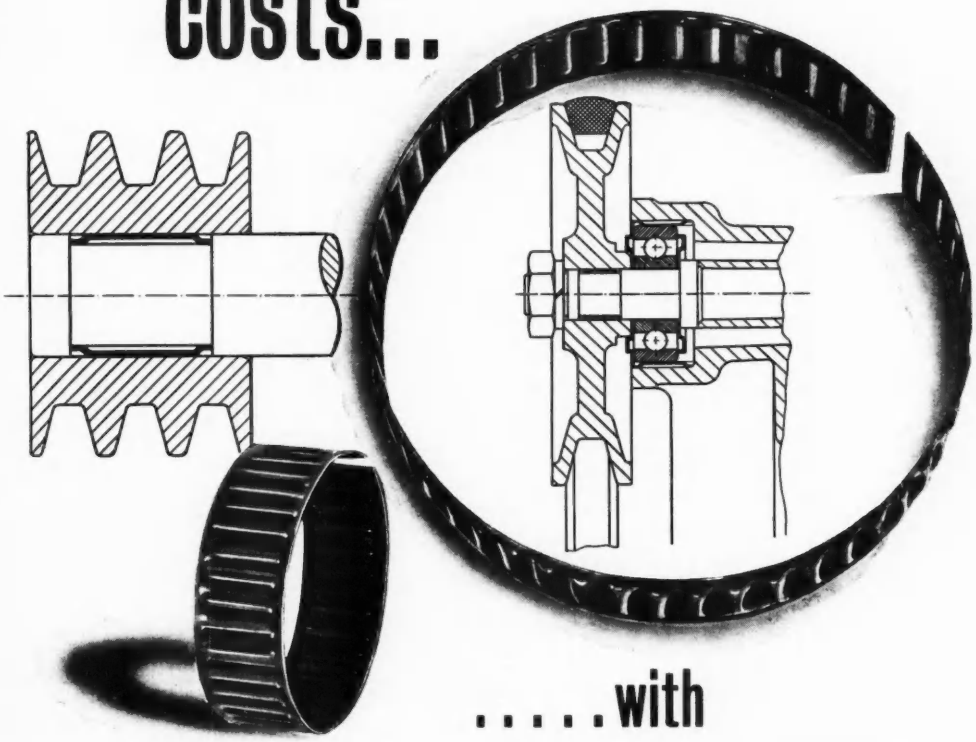
life-time quality die-castings

CONSULT

WM. COULTHARD & CO. LTD. DURRANHILL, CARLISLE · 21418

★ Cut assembly costs...

Star Tolerance Rings, made from hardened and tempered spring steel, are corrugated to give firm fastening between machine parts. Simple to fit, they allow wider tolerances on machined parts. . . . can effectively transmit very high torque or take up any differential thermal expansion which might occur between components of dissimilar metals.



Available in a wide selection of sizes Star Tolerance Rings provide simple efficient means of fixing:

- *Lever knobs, handles, etc.*
- *Pulleys, etc., to shafts avoiding the use of splines or keyways.*
- *Ball or roller bearings in housing bores.*

Our Technical Department will be only too pleased to prepare drawings, illustrating the use of Star Tolerance Rings in your equipment. Please send for full details and trial samples of these money and labour-saving fittings.

.....with STAR TOLERANCE RINGS

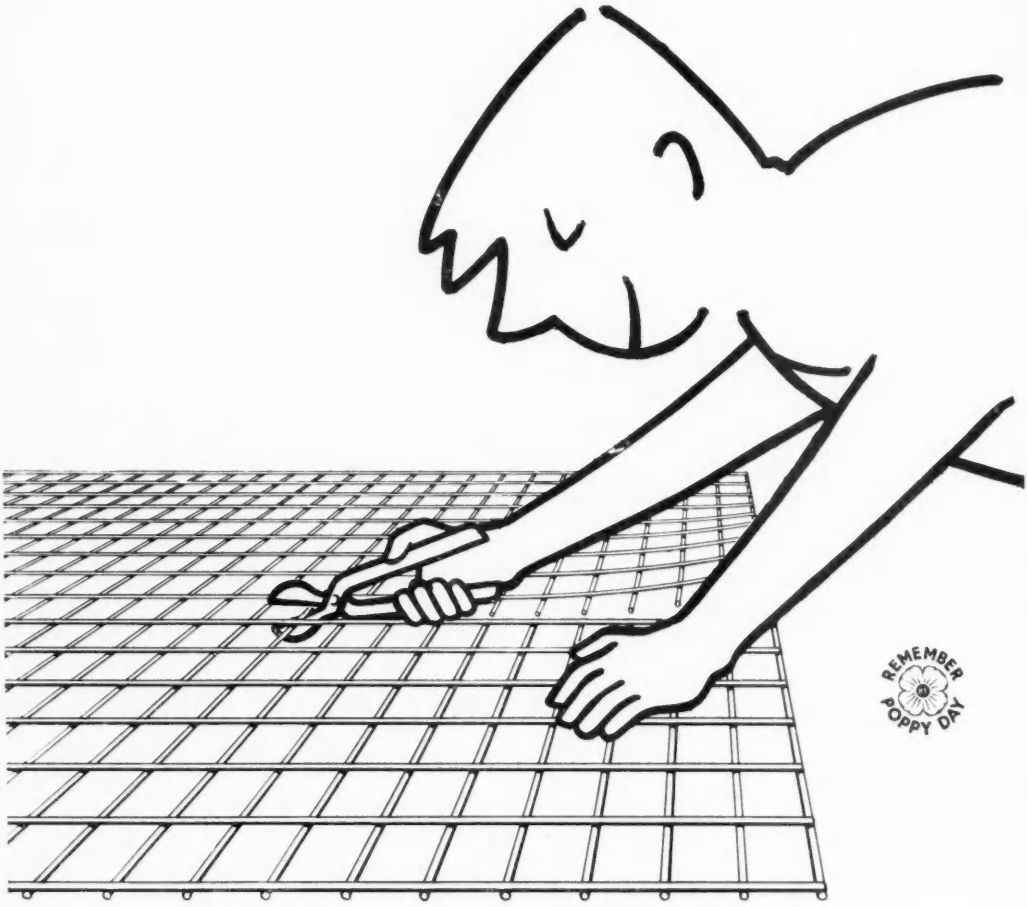
GEORGE ANGUS & Co LTD

OIL SEAL DIVISION

COAST ROAD, WALLSEND-ON-TYNE, ENGLAND

Tel: 624551. Grams: "Gaco, Wallsend". Telex Gaco, Wallsend 53-138

A56/60



here is a man cutting costs
and solving his guard problems with

Weldmesh

Regd. Trade Mark

Cut it to the shape you want—
it holds together because it is welded together

Weldmesh is a registered trade mark and is supplied direct to users by the sole manufacturers:

THE B.R.C. ENGINEERING COMPANY, STAFFORD

London, Birmingham, Bristol, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast, Bulawayo, Calcutta, Johannesburg, Singapore, Vancouver.

Export Sales: 54 Grosvenor Street, London W.1

H-W. 187

There is a saying that whereas there are
a hundred ways of doing a thing wrongly
there is only one way of doing it correctly.

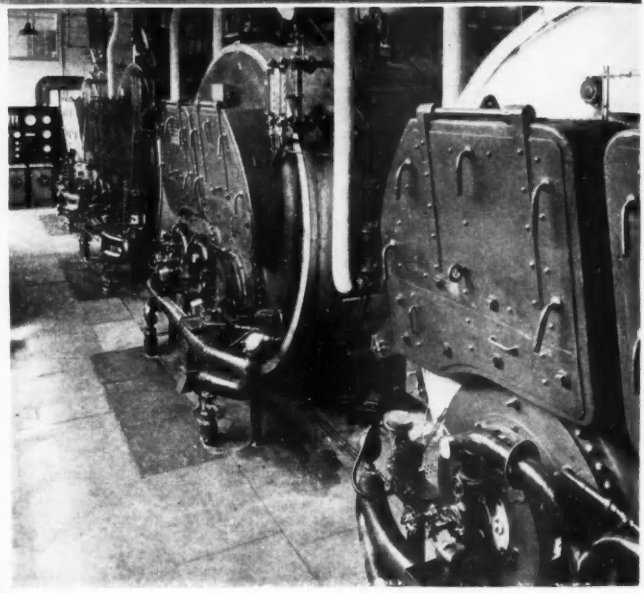
GKN have one way of making fifty or sixty thousand different fastenings—the right way.

GUEST KEEN & NETTLEFOLDS (MIDLANDS) LTD., BOLT & NUT DIVISION: ATLAS WORKS, DARLASTON S. STAFFS.
TELEPHONE: JAMES BRIDGE 3100 (10 LINES) TELEX: 33-228

D/GB/442

ROTAVAC Oil-firing

Photos by courtesy of Queen Mary's (Roehampton) Hospital. Boiler plant includes four Marshall Three-pass Economic boilers each fired with two Rotavac No. 3 WSF Burners.

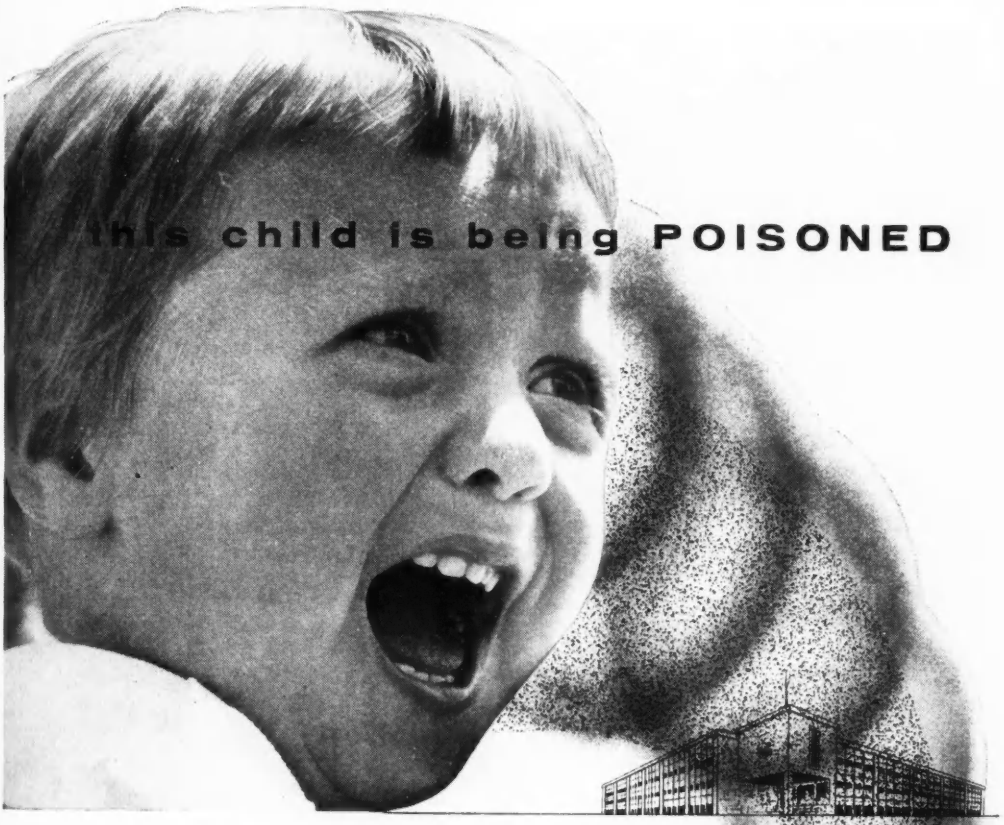


ROTAVAC OIL BURNER TYPE WSF

Hospital service calls for the utmost in efficiency and reliability—service that the world of public undertakings and industry has learnt to expect from Rotavac oil-firing. Rotavac provides high efficiency atomisation with minimum maintenance (no moving parts), perfect flame form, automatic control and the economy of the cheapest liquid fuels. Backed by nation-wide spares and after sales service.

NU-WAY HEATING PLANTS LTD., (Box B359) DROITWICH

and at: LONDON, MANCHESTER, NEWCASTLE, GLASGOW, BELFAST, DUBLIN, BRISTOL



In buildings without filtration or where filtration systems are inefficient, germ laden air still poisons our children. In factories, adults too are subjected to deadly poisons through air pollution.

Where Far-Air Filtration has replaced conventional systems, 99.5% filtration efficiency has been obtained. Far-Air filters have a much longer life than conventional systems and annual costs are considerably reduced.

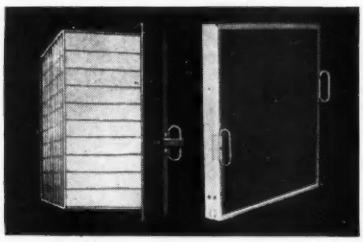
MEMBER OF THE BIRFIELD GROUP

INTERMIT LIMITED

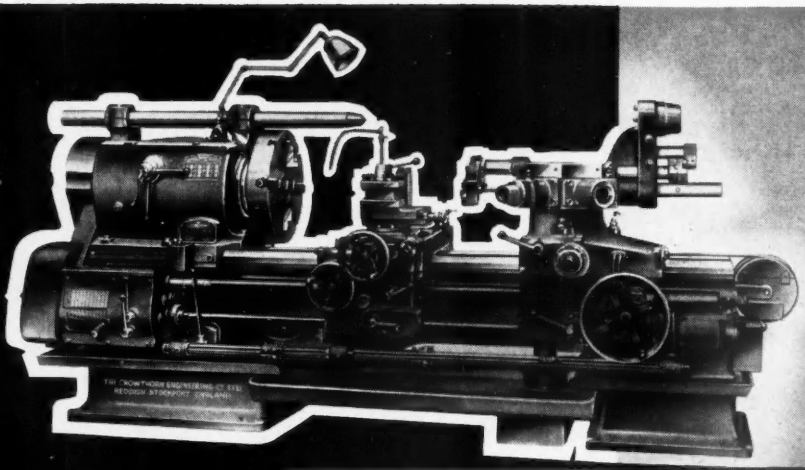
Far-Air Licensed Manufacturers for Europe

BRADFORD ST · BIRMINGHAM 5

FIT FAR-AIR FILTERS



The illustration shows a standard panel filter and an H.P. After Filter— fully illustrated literature is available.



CROWTHORN

HIGH PRODUCTION LATHES

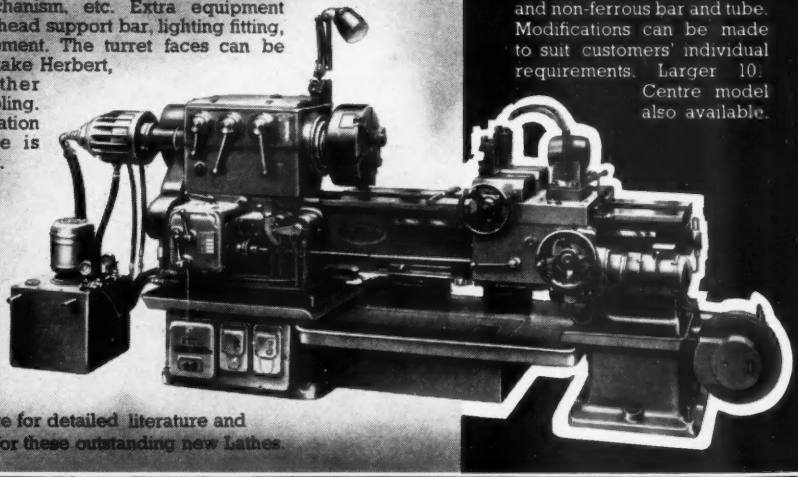
* * * * *

'Crowthorn' 10" Centre and 12" Centre Combination Turret Lathes

The model illustrated above is the 'Crowthorn' 12" Centre Combination Turret Lathe with standard equipment including fourway toolpost, rear single toolpost, hexagon turret, automatic trip mechanism to sliding and surfacing motions of main saddle and to sliding motion of turret saddle, quick power traverse mechanism, etc. Extra equipment includes overhead support bar, lighting fitting, tooling equipment. The turret faces can be machined to take Herbert, Ward or other standard tooling. An 8" Combination Turret Lathe is also available.

'Crowthorn' 8" Centre Turning, Boring and Parting-off Lathe (below)

Used extensively for machining cylinder liners, turning, boring and parting-off ferrous and non-ferrous bar and tube. Modifications can be made to suit customers' individual requirements. Larger 10" Centre model also available.



* Please write for detailed literature and quotations for these outstanding new Lathes

CROWTHORN ENGINEERING COMPANY LIMITED

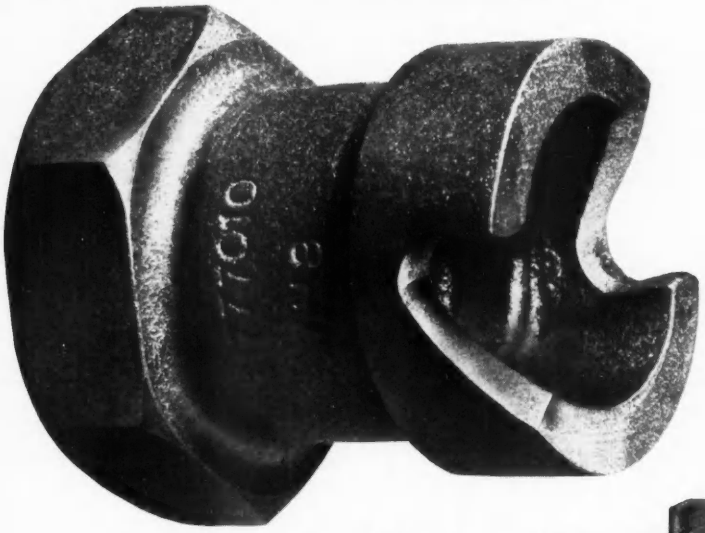
Makers of High Class Machine Tools for over half a century

REDDISH · STOCKPORT · ENGLAND

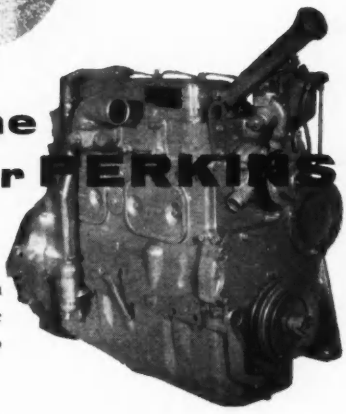
Phone : STOCKPORT 7271-2-3 *Grams: CROWTOOL, REDDISH*

CL. 115

This HARPER CASTING



cuts machining time on a component for PERKINS by nearly 80%



It used to take 14½ minutes to machine a starting dog from hexagon bar . . . now, using Harper S.G. Iron Castings the time has been reduced to 3 minutes, thus contributing to greater productivity.

This Spheroidal Graphite Cast Iron turning dog for the Perkins L4 & Four 270 Diesel Engines has been fully tested by F. Perkins and has adequate tensile strength and also the necessary wearing qualities to permit the engine to be turned by hand, through a turning handle, when required for maintenance purposes.

HARPER CASTINGS

You are invited to send for Harper's latest illustrated brochure of Castings in grey iron, spheroidal graphite and Meehanite (Regd. Trade Mark); metal pressings, machining, enamelling and sub-assembly work. On Lloyd's list for S.G. Iron Castings.

CASTINGS WITH THE HARPER SKIN
FOUNDED 1790

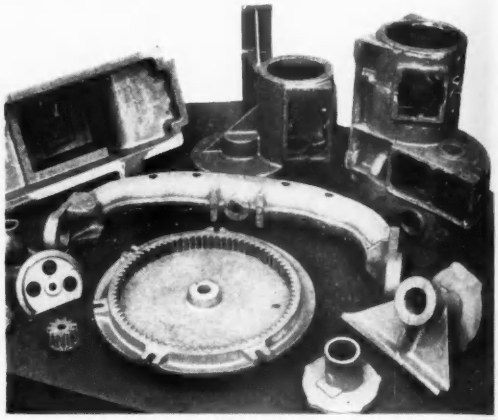
JOHN HARPER & CO. LTD.

WILLENHALL • STAFFS • *Phone:* WILLENHALL 124 (5 lines)
LONDON, *Phone:* ABBey 5906/7 MANCHESTER, *Phone:* BLAckfriars 0295
Also makers of the famous Beatrice Oil Heaters and Harper Housewares

H676

NEWTON CHAMBERS

cast in all grades of MEEHANITE from a few pounds to 20 tons

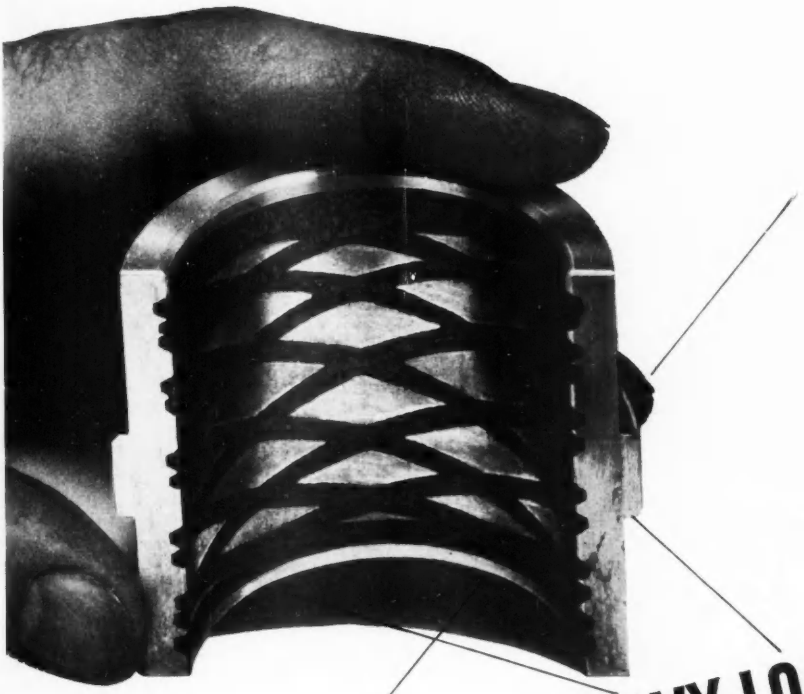


Whether you require one casting or thousands, up to 20 tons each or as little as a few pounds each, for any service in any grade of Meehanite, *we can meet your needs*. Our foundry facilities are extensive, and include machine moulding, shell moulding, loom moulding and floor moulding, and with our 160 years' experience of serving every major industry, we are able to offer an exceptionally skilled and comprehensive service. *All enquiries will receive immediate attention.*

Newton Chambers

NEWTON CHAMBERS · ENGINEERING DIVISION
THORNCLIFFE · SHEFFIELD

ENGINEERS OF PROGRESS

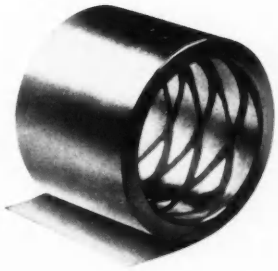


FOR HARD USAGE and HEAVY LOADS

GRAPHITED BRONZE BEARINGS

ARE THE BEST!

For hard usage, and wherever ordinary oil or grease lubrication is liable to fail, Graphited Bronze Bearings manufactured by Bound Brook Bearings Ltd., provide the complete answer. They cover the shaft with a smooth, durable film of graphite lubricant, made from graphite developed from a special formula by Bound Brook and perfected after many years of experience. These Graphited Bearings are specially suited to inaccessible installations or for high temperatures, severe static loads, immersion in liquids or exposure to dust or weather. If you send us details of your bearing problem we can recommend the most satisfactory type from a large range of successful applications.



TYPICAL USES:
Agricultural Machinery • Conveyor Systems • Food Machinery • Baking Equipment
Cranes • Lock Gates • Furnace Chargers • Oven Equipment • Earth Moving Machines

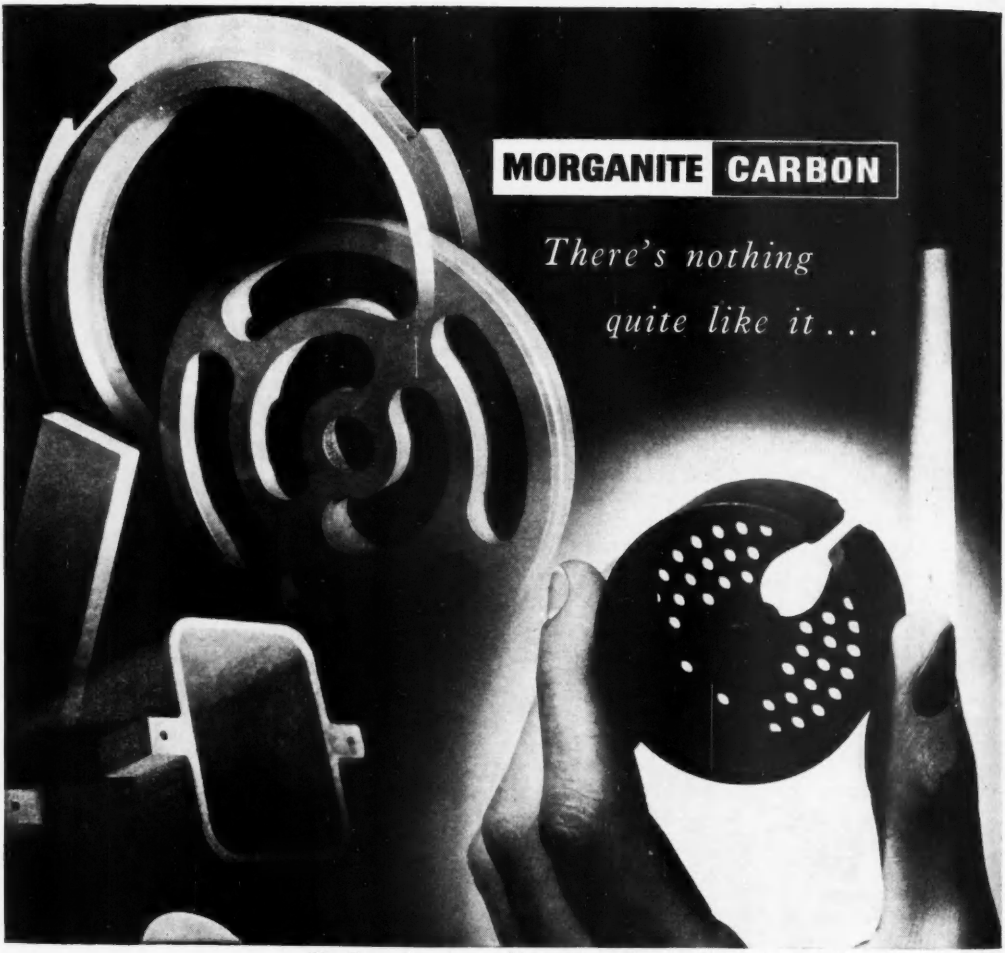
Other well-known Bound Brook products include: 'Lubrook' oil-retaining Porous Bronze Bushes, Bearings and Parts. 'Ferrocite' oil-retaining Porous Iron, Bushes, Bearings and Parts. Sintered Metal Parts and Components by Powder Metallurgy. Bound Brook Bronze Filters, Sintered Brass Parts. 'Polyslip' P.T.F.E. Impregnated Bearings.

Send for our leaflet 'BOUND BROOK Graphited Bronze Bearings'

BOUND BROOK BEARINGS LIMITED

Trent Valley Trading Estate, Lichfield, Staffordshire
Telephone: Lichfield 2027-8 *Telegrams:* BOUNDLESS Lichfield

Member of the
Birfield Group



The illustration shows a Water Meter Piston, a Valve Anode, a Pump Vane, a Sealing Ring, a Rectifier Grid and a Welding Rod — just a small selection of products showing the remarkable versatility of Morganite Carbon.

. . . *that's the beauty of it*

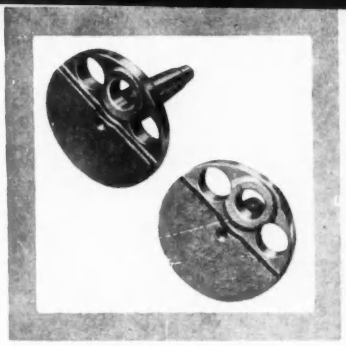
Look at these advantages — Light as aluminium. High resistance to wear. Wide range of resistance to chemical attack. Easily machined. High thermal conductivity. Excellent heat radiation. Not wetted by molten metal or slags. Non-seizing. Self-lubricating. High resistance to thermal shock. Good mechanical strength at high temperatures. Good electrical conductivity. Available in impervious forms. Low thermal expansion. These properties give Morganite Carbon vast potentialities for the design engineer. Talk them over with our technical staff.

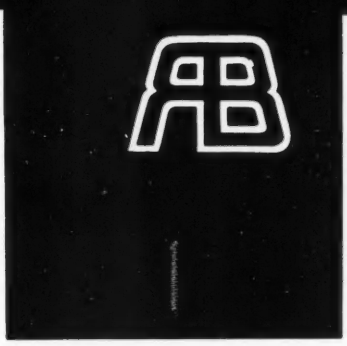
MORGANS

CARBON AND GRAPHITE — ELECTRICAL, CHEMICAL AND MECHANICAL; CRUCIBLES, FURNACES, REFRACTORIES; RADIO PARTS; SINTERED METAL PRODUCTS AND ELECTRIC FURNACE ELEMENTS.

THE CARBON DEPARTMENT
THE MORGAN CRUCIBLE CO. LTD., BATTERSEA CHURCH ROAD, LONDON, S.W.11. **BAT: 8822**
C59A/417

VERTICAL DRILLING MACHINE

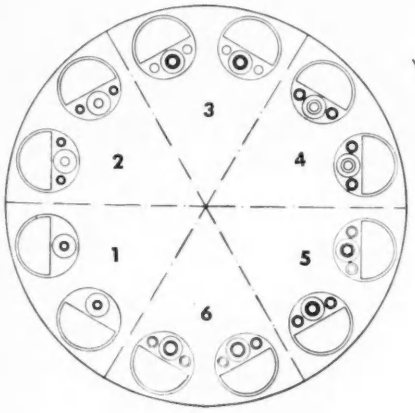




VC III G

multiple spindles on jig bored support plate.
Floor to floor time for 2 pieces: 52''

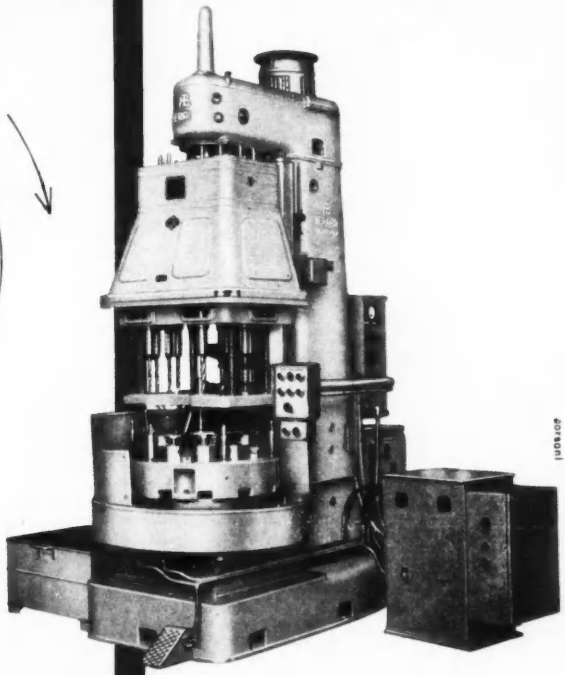
Machining cycle



load station

Components: crankshaft shoulders, pinion and flywheel ends.

Station	Operation
1	Drill central hole
2	Drill lateral holes
3	C' sink (both sides)
4	C' sink (both sides)
5	Ream central hole
6	Load and unload



OFFICINE **RINO BERARDI** · BRESCIA · ITALIA
VIA ALESSANDRO LAMARMORA, 105 · TELEFONO 55 3 52

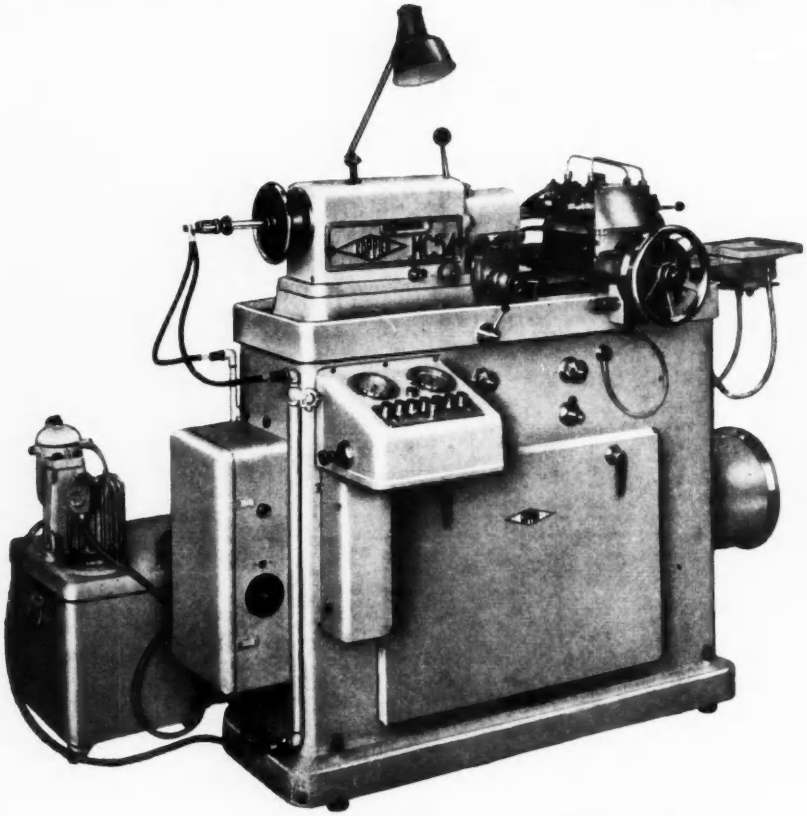
(Associata all' U. C. I. M. U.)

BERARDI

INTERNAL GRINDER

for production of Injectors
and high-precision components

FRATELLI COPPIER MILANO



TECHNICAL CHARACTERISTICS

Internal grinder for holes of 1 to 20 mm diameter in high-hardness alloys, e.g., gauges, dies, etc. Spindle speeds from 60,000 to 140,000 rpm.— Quick adjustment for control of diameters, with automatic feed of the spindle head: automatic stop — Supply voltage according to requirements. Weight of complete Grinder approx. 750 kg.

CONSTRUCTIONAL FEATURES

Grinder specially designed for the mass production of injectors of any type for the internal grinding of gauges and dies in tungsten, carbide and other alloys, for work requiring a very high degree of precision of the order of 0·0003 mm both in roundness and centricity with surface micro-roughness of 0·00025 mm. Perfectly smooth surfaces are obtained, in view of the complete absence of harmful vibrations The perfect finish of the surfaces, combined with exact geometrical shape, is always assured by the M.C.54 Grinder fitted with patented M.C.52 "Turbo Spindles", with automatic take-up of bearing play, oil-mist lubrication, and other features introduced into its construction. All the adjustments of the individual members of the machine are hydraulically controlled. The machine is fitted with turbine-driven spindles of very high rotational speeds, from a minimum of 60,000 to a maximum of 140,000 rpm; one of these spindles serves to grind cylindrical parts and the other conical parts (e.g. injector and valve seats) according to requirements.

The rotating spindle unit of the M.C.52 "Turbo Spindles" employ a small turbine and the hydraulic system adopted, as compared with electrically-driven spindles, affords numerous advantages, including the following :—

- **— simplicity of construction.**
- **— variable speed range between the limits required, depending upon the internal dimensions to be ground.**
- **— normal operating speed : 120,000 — 130,000 rpm.**
- **— speed variation between full and no load about 3-4 per cent.**
- **— extremely simple automatic lubrication, without the need for cooling equipment.**
- **— possibility of grinding diameters from 1 to 20 mm.**
- **— automatic take-up of bearing play by means of a patented device which guarantees longer life to the bearings.**
- **— operating life of the spindle at least 800 working hours guaranteed.**
- **— high-precision grinding and finishing of the parts.**

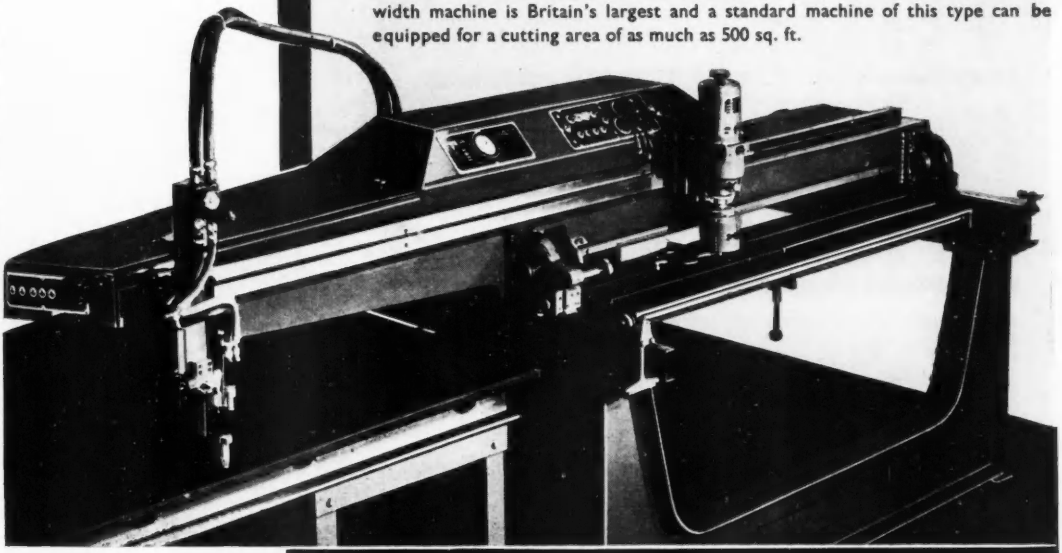
FRATELLI COPPIER-MILANO (ITALY) PIAZZA CARRARA, n.15

Phone : 84.90.386

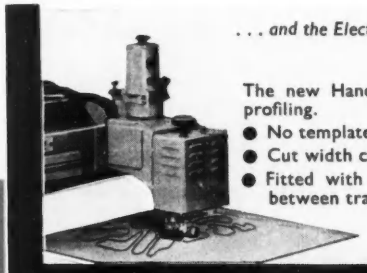
Cut a fine figure . . .

The new Hancomatic embodies the best principles of oxygen cutting in a handsome, streamlined machine. With the Hancomatic it's top speed precision cutting every time and saving in time and labour all along the line. New electrically operated oxygen cutting valve with instant shut-off, new tracer head for operation from templates of all types.

The Hancomatic is available in 40″, 62″, 90″ and 120″ cutting widths; the 120″ width machine is Britain's largest and a standard machine of this type can be equipped for a cutting area of as much as 500 sq. ft.



with the HANCOMATIC
OXYGEN CUTTING MACHINE



. . . and the Electronic **HANCOLINE** *which traces from a pencil drawing automatically*

The new Hancoline brings absolute simplicity to oxygen profiling.

- No templates needed—no storage problems.
- Cut width compensation on tracer head.
- Fitted with Hancock roller drive—no physical contact between tracer and drawing.

Available with 38″, 60″, 90″ and 120″ cutting widths.

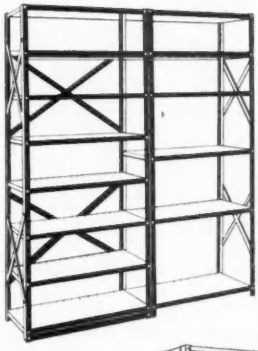
Write for details

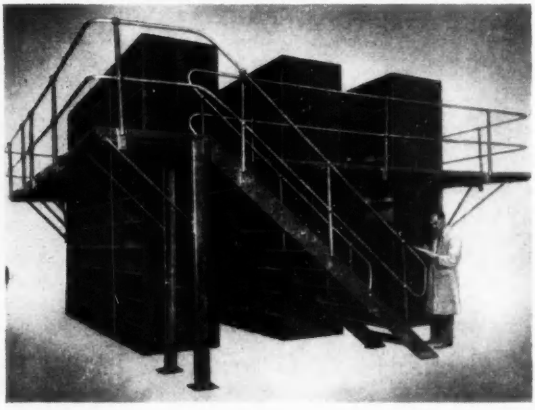
HANCOCK & CO. (Engineers) LTD

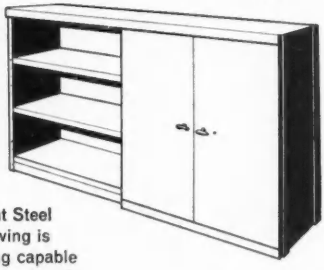
Progress Way, Croydon, Surrey Telephone: Croydon 1908 · Cables: Hanco Croydon

TIB 175A

SHELVING YOUR PROBLEM







If the problem is storage there's an economical answer—Evertaut Steel Shelving. Available in a multi-purpose range Evertaut Steel Shelving is space-planned for efficiency, the units within each category being capable of infinite variation in arrangement. The range includes open type, closed type, light warehouse shelving, multi-tier shelving, ledge type, counter shelving, Hinged and sliding doors are included in the range.

EVERTAUT
STEEL SHELVING

POST COUPON FOR CATALOGUE!

To: Evertaut Ltd., Walsall Road,
Perry Barr, Birmingham, 22B.

Please send me your Shelving Catalogue.

NAME_____

ADDRESS_____

_____ E

Problem: HEAT

Solution: COLT Ventilation

Place: LEYLAND MOTORS LIMITED
LEYLAND LANCASHIRE

The Architects, Messrs. Harry S. Fairhurst & Son F/A.R.I.B.A. who designed this factory for Leyland Motors Ltd. installed Colt Ventilators throughout for three reasons:
1. They had confidence in Colt Ventilation from past experience.
2. They liked the low silhouette which would not impair the appearance of the building.
3. The installation weighed 72 tons *LESS* than any other ventilation equipment available, thereby showing considerable saving in structural costs.
In providing a permanent solution to this ventilation problem Colt have added yet another chapter to their record of success—success which has brought repeat orders from many world-famous concerns. Send for a free Data Manual to Dept.

COLT VENTILATION LIMITED SURREY TELEPHONE: ELMBRIDGE 0161

Churchill

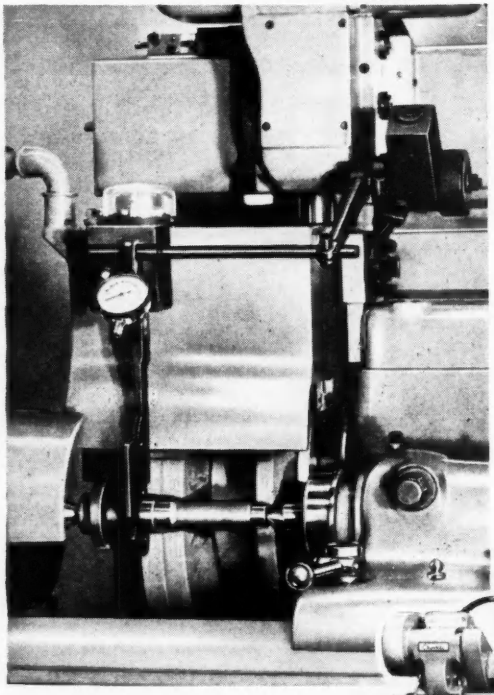
AUTOMATIC

SIZING OF WORKPIECE

TRUING OF GRINDING WHEEL

COMPENSATION FOR WHEEL TRUING

CYCLE CONTROL FOR NUMBER OF WORKPIECES

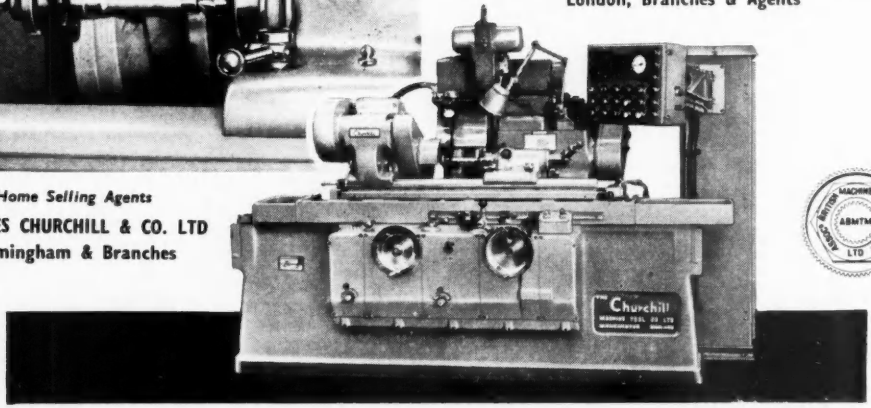


on

Model 'BW' Plain Grinding Machine

THE CHURCHILL MACHINE TOOL Co Ltd
Broadheath, nr. Manchester.
Altrincham 3262

Export Sales Organisation
ASSOCIATED BRITISH MACHINE TOOL MAKERS LTD
London, Branches & Agents



Home Selling Agents
CHARLES CHURCHILL & CO. LTD
Birmingham & Branches

C675A

....almost everyone thought of them first

The Chinese invented everything from writing to rockets.... so they say. They may have pipped the ancient Egyptians; they certainly used them hundreds of years B.C.. The Romans knew about them and used them. As usual, the Greeks had a word for them. Even the Monks of the Middle Ages who discovered so many things may well lay claim to the invention of gears. But whoever thought of them first, lots of people make gears now. OPPERMANS OF NEWBURY FOR EXAMPLE. And as in everything else, some people make things better than others. OPPERMANS OF NEWBURY FOR EXAMPLE. Oppermans (of Newbury, you will remember) don't claim to have thought of gears first; but they think of little else now.

OPPERMANS OF NEWBURY

OPPERMAN GEARS LTD NEWBURY BERKSHIRE Telephone Newbury 1701 Telegrams Oppigears Newbury

TELESIG

SCREW PUMPS

TELESIG Screw Pumps are positive displacement pumps. Simply constructed, they offer exceptional performance and long life. TELESIG pumps effect delivery by means of three parallel screws engaging each other, the power-driven central screw driving the two side screws. They may be run at high speed thereby reducing motor sizes and installation costs.

TELESIG Screw Pumps offer the following advantages:

- Self priming.
- Delivery free from pressure pulsation.
- High working speed — small size.
- Near-silent operation.
- Simple construction.
- Minimum maintenance and easy replacement of working parts.
- Long life.

TELESIG Screw Pumps are made in three basic ranges: for low pressures up to 300 psi, for medium pressure up to 1000 psi and for high pressures up to 2,500 psi. 42 sizes are available covering a wide range of capacities.

TELESIG

Screw Pumps by Telehoist

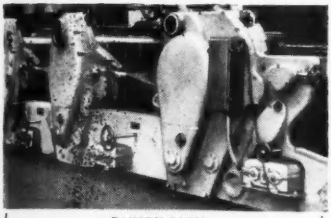
TELESIG pumps and equipment are made by Telehoist under licence from the Swiss Industrial Company (SIG).

Telehoist Limited. Cheltenham England. Telephone: Cheltenham 53254

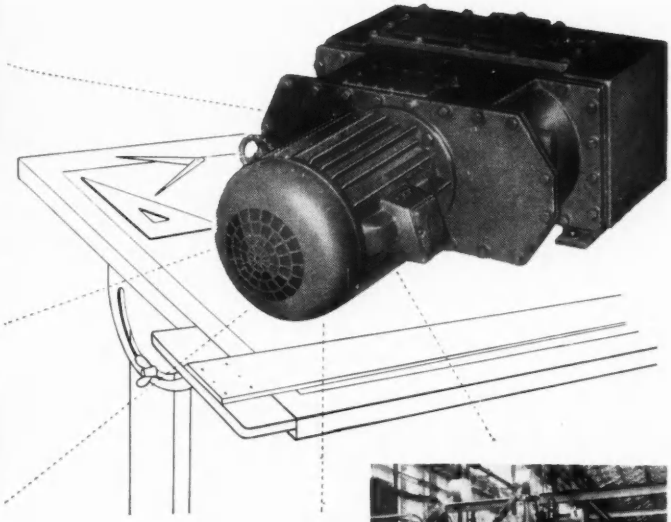
an associate company of Wilmot Breeden Ltd.

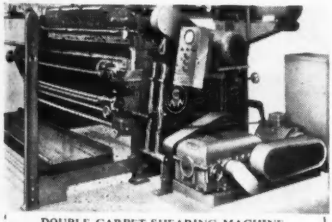
POSITIVE INFINITELY VARIABLE SPEED CONTROL

Wherever precise speed control is a factor of major importance in a manufacturing process, the P.I.V. Drive can be relied upon implicitly. For more than 30 years P.I.V. Gears have been meeting and solving just such problems with an outstandingly high level of accuracy and reliability. In the P.I.V. Gear power is transmitted *positively* through an all-metal chain making tooth-to-tooth contact with metal discs. Slip is virtually impossible and the uniformly high efficiency remains unimpaired throughout years of use.

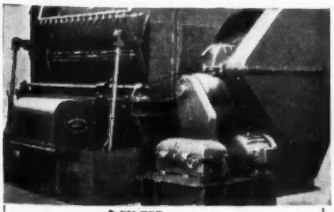


BAKERY OVEN
Courtesy T. & T. Vicars Ltd.

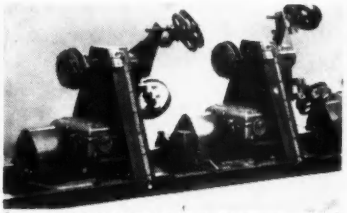




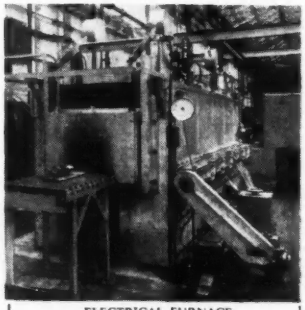
DOUBLE CARPET SHEARING MACHINE
Courtesy William Whitely & Sons Ltd.



FILTER
Courtesy Davey Paxman & Co. Ltd.



RUBBER TAPE LAPPING MACHINE
Courtesy B. & F. Carter & Co. Ltd.



ELECTRICAL FURNACE
Courtesy General Electric Co. Ltd.

Write for literature giving full list of available ratios, power rating tables, etc.

STONE-WALLWORK LTD.

32 VICTORIA ST. LONDON S.W.1

Telephone Abbey 7681 Telegrams Stonwalabb London

WORKS: BLEASBY STREET, OLDHAM, LANCASHIRE

STONE PLATT GROUP

Also manufacturers of Worm Reduction Gears, Piece Goods Stamping Machines and Light Alloy Bobbins for the Textile Trade.

Job for the Specialists

These narrow angle gears were designed and developed by ENV in co-operation with D. Napier & Son Ltd for the V-drive units used with Deltic engines of 1620 h.p. The gears are of case hardened alloy steel, and the teeth are profile ground to provide the accuracy essential at the high peripheral speeds attained.

ENV are specialists in spiral bevel and hypoid gears for automotive, aviation, railway traction, marine propulsion and industrial applications. They pioneered the Gleason system in this country and have unequalled experience in this highly specialised branch of gear manufacture. Their works are equipped with the latest Gleason machines and associated plant for the manufacture of spiral bevel, hypoid and zerol gears from 1″ to 72″ diameter.

ENV for gears

ENV engineers will be pleased to advise on problems associated with gears and drives, especially where bevel gears are used.

E N V ENGINEERING COMPANY LIMITED, Hythe Road, Willesden, London, N.W.10. Telephone: LADbroke 3622

AP 104

collet troubles on high-speed automatics?

decarburised surface areas on black rolled stock?

heavy machining costs due to irregular surface?

high tool-room costs in making punches, dowels, ejector pins, etc?

LET KE SOLVE YOUR PROBLEMS . . .

by using drawn and ground KE SPECIAL STEELS

Supplied in lengths, drawn and centreless ground, ¼"—2" diameter, within close tolerance of size, KE Special Steels are available in a wide range of High Speed, Tool, Stainless and Alloy Steels, including such qualities as

KE A 108 Free Machining 1% Carbon Silver Steel

KE 40 A M Free Machining Stainless Iron

Both the above qualities give great increases in machining speeds.

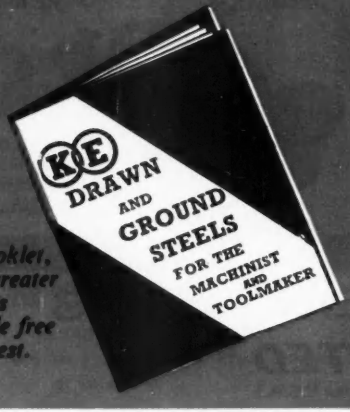
KE Electrically melted Silver Steel, to B.S.S. 1407.

KE LOCK 237 18% Tungsten Vanadium High Speed Steel (18/4/1).

KE 839 1% Carbon 1½% Chrome Oil Hardening Alloy Tool Steel.

KE 805 Direct Oil Hardening Nickel Chrome Molybdenum Steel.

We specialise in the supply of material for work demanding high grade steels, regular in quality and performance, and accurately drawn and centreless ground to size.



This booklet, giving greater detail, is available free on request.

KAYSER ELLISON & CO. LTD

ESTABLISHED 1825

CARLISLE STEEL WORKS · SHEFFIELD

LAST YEAR GT. BRITAIN CONSUMED

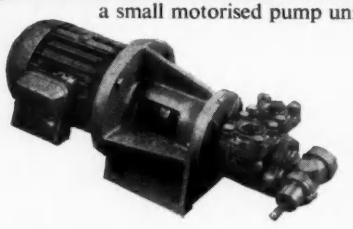
36½

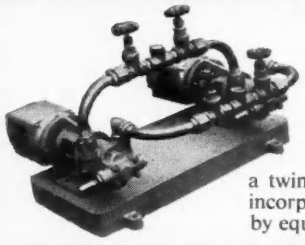
MILLION TONS OF OIL
AN INCREASE OF 10%

VARLEY PUMPS

are handling a larger proportion than ever

a small motorised pump unit





a twin pumping set incorporating stand-by equipment

MOTORISED GEAR PUMPS

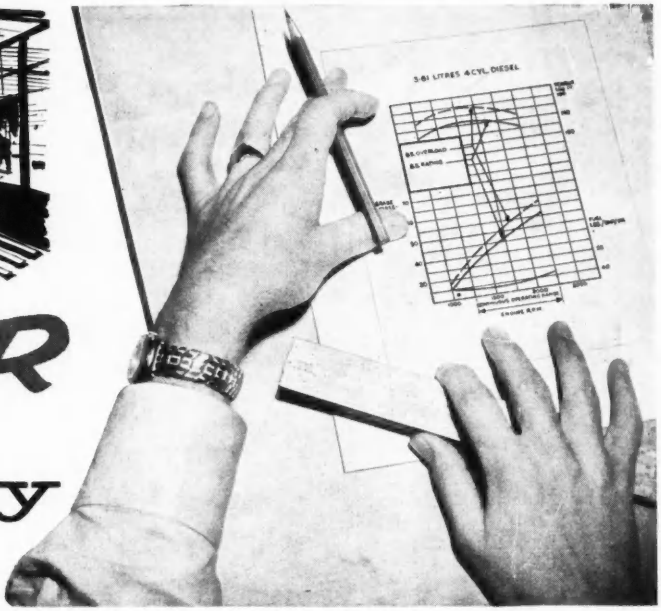
VARLEY–FMC LIMITED

(Subsidiary of Food Machinery and Chemical Corporation U.S.A.)

FERRY LANE BRENTFORD MIDDLESEX *Telephone: ISLEWORTH 3922 (6 lines) Telex No. 25371 Telegrams: Paracyclic Brentford Telex*

P.4967

POWER for industry



Our range of industrial engines are a practical proposition for many types of industrial equipment **... compressors, cranes, pumps, contracting equipment, earth borers, generators, railcars, welding plant, works trucks, tractors and conversions.** Simple design, modern flow-line production methods and common interchangeable parts contribute to the low cost of these high efficiency engines. And remember, every engine is fully backed by a World-wide Parts and Service Organisation. Take your choice from a wide power range ... Diesel 20 to 86 b.h.p. and Petrol 11 to 87 b.h.p. (12-hr. rating).

DIESEL ECONOMY—have you considered the replacement of existing power units in your equipment and trucks with the famous 4D Diesel engine? You'll have the unique advantages of economy, long-life and low running costs ... plus the best service in the World!

Wherever you are, whatever your problem,

FORD

MOTOR COMPANY LIMITED · ENGLAND

are at your service

For further details of our

INDUSTRIAL ENGINES

and the equipment they power, send the coupon to your nearest Ford Dealer or direct to

Please send me technical brochures of your *PETROL/DIESEL Industrial Engines. The maximum B.H.P. required is.....at.....R.P.M. Also, please send details of the following equipment powered by your engines.

.....

.....

Name .....

Address .....

.....

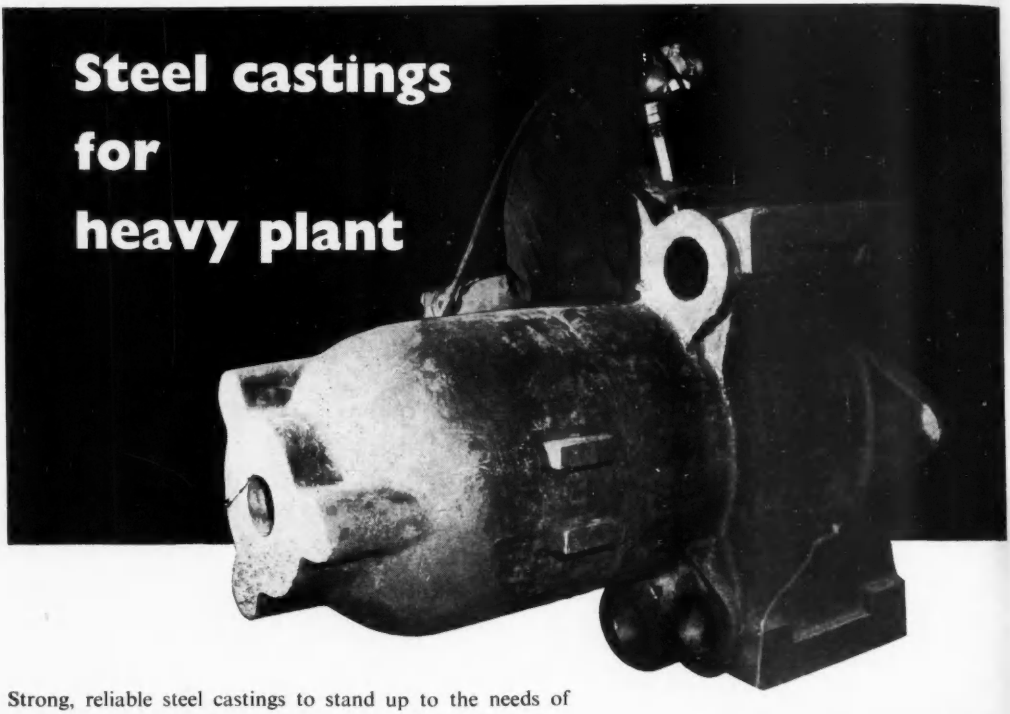
Nature of Business .....

..... **Telephone No.** .....

**Delete where not applicable* G51·24·11

FORD MOTOR COMPANY LTD · PARTS DIVISION (G51) · AVELEY DEPOT · SOUTH OCKENDON · ROMFORD · ESSEX · ENGLAND

Steel castings for heavy plant



Strong, reliable steel castings to stand up to the needs of heavy plant: for hydraulic work soundness is specially important. At the Edgar Allen Steel Foundry, we are experienced in this kind of work and many producers of heavy engineering plant entrust their steel casting requirements to us.

The illustrations show (above) a cast steel main cylinder (weight 23,940 lb.) for a 1000 ton hydraulic extrusion press and (right) a cast steel platen (weight 18,325 lb.) for a 1100 ton press. Both are made for The Loewy Engineering Co. Ltd., Bournemouth.

EDGAR ALLEN & CO. LIMITED

IMPERIAL STEEL WORKS · SHEFFIELD 9

TO **EDGAR ALLEN & CO. LTD., SHEFFIELD, 9.** F82/ED.

Please post Steel Foundry Book to :

NAME .....

POSITION .....

FIRM .....

ADDRESS .....

The Edgar Allen Steel Foundry Book gives useful data and particulars of our facilities for producing steel castings from a few ounces to a finished weight of 14 tons.

Teleflex it!

TELEFLEX manufacturing resources are spread throughout Europe—Great Britain, France, Western Germany, Italy, Spain and the Netherlands. There is a complete interchange of technical experience enabling the latest practices in mechanical handling to be made available to a world-wide clientele.

Chain, Slat, Roller, Belt Conveyors, etc. for factory installations.

Let Teleflex Conveyors become "The Invisible Men" in *your* factory. Our representatives are available anywhere at short notice

Teleflex

The EXPERTS IN MECHANICAL HANDLING

TELEFLEX PRODUCTS LIMITED · P.O. BOX 1 · BASILDON · ESSEX

Tel: Basildon 20581 · *Grams:* TELEFLEX PHONE BASILDON
Midlands Office: 57 Warwick Road, Birmingham 11 · *Tel:* Victoria 5333

P3706

GAMAX

One of the hundreds of Gamax Gear Units installed in the factory of W. D. & H. O. Wills

THE GREAT LITTLE Gear Unit

give smooth, efficient service in light industry

For packaging cigarettes and for almost any other light industrial tasks requiring a range of $\frac{1}{2}$ to $1\frac{1}{2}$ max. h.p. (18-896 r.p.m. output speed) these compact Gamax Gear Units excel. Incorporating straight line drive with high quality Durangus non-metallic planet pinions they provide really silent, vibration-free operation . . . *and because conventional oilbath lubrication is completely dispensed with, all fear of leakage or contamination is eliminated.* The sealed bearing assembly is prepacked with grease to ensure at least two years trouble free running under normal conditions . . and these compact units can be amounted at *any* angle without in any way impairing their efficiency.
Competitive in price, these outstanding gear units are available to give efficient, quiet and trouble-free service in any light industrial application.

ALSO IN REGULAR PRODUCTION ARE :

Spur and Helical Gears up to 78 in. diameter
Double Helical Gears up to 5 ft. diameter
Worm Gears up to 24 in. centres
Bevel Gears up to 5 ft. diameter
Profile Ground Spur, Helical and Worm Gears
Durangus and Peak Non-Metallic Silent Gears
Rawhide Silent Pinions

GEAR UNITS OF ALL KINDS TO SPECIAL REQUIREMENTS

GEORGE ANGUS & Co LTD
GEAR DIVISION
PRINCE CONSORT ROAD, HEBBURN, CO. DURHAM
Telephone: Hebburn 832204 Telegrams: "Gamesh" Hebburn

ECONOMY WITH RELIABILITY

The 40M. Three speed and reverse, constant mesh unit is capable of accepting up to 60 lb./feet. Extremely robust, for very arduous conditions; suitable for dumpers, tractors, towing tugs, etc., where long periods of running in the indirect gears are required. Supplied with or without bellhousing to suit a standard 8" Borg & Beck clutch and 5. S.A.E. engine mounting. Also supplied with reduction unit on the output end, giving an additional reduction of up to 3:1.

P. R. MOTORS LTD.

ALDBOURNE ROAD, COVENTRY

Telephone: 22266/7. Telegrams: Supagears, Coventry

SPECIALISTS IN VEHICLE GEAR BOXES SINCE 1902

NO MORE D. C. MOTOR PROBLEMS !

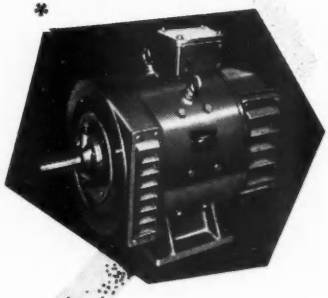
E.P.E. turn D.C. problems into D.C. motors * ....

Not long ago, many people thought it impossible to get D.C. motors quickly and at a reasonable price. Some people still think so.

They don't know about E.P.E.

E.P.E. specialise in D.C. equipment, combining their many years experience in this field with a keen interest in new techniques. They can supply D.C. motors and generators of any enclosure quickly and at a reasonable price

If you've a D.C. motor problem, why not bring it along to E.P.E? If they haven't a solution in stock, they'll be happy to make one for you !

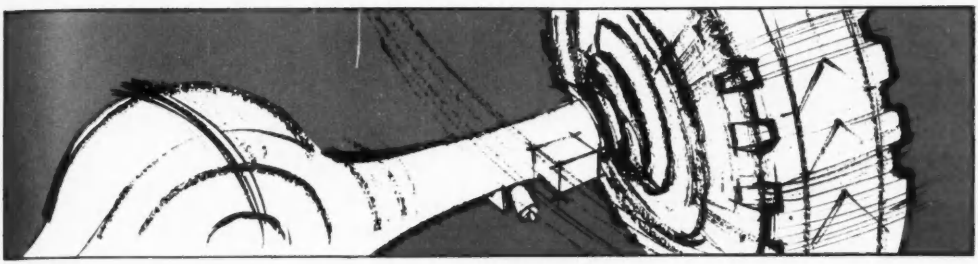


E·P·E

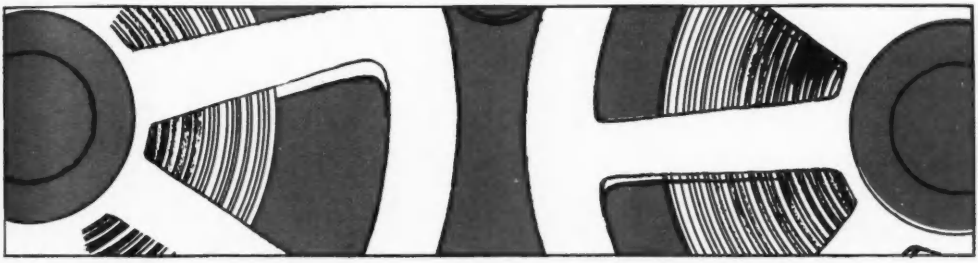
ELECTRICAL POWER ENGINEERING CO. (B'ham) LTD.
Bromford Lane, Birmingham 8

'Phone : STEchford 2261
'Grams : Torque 'Phone Birmingham

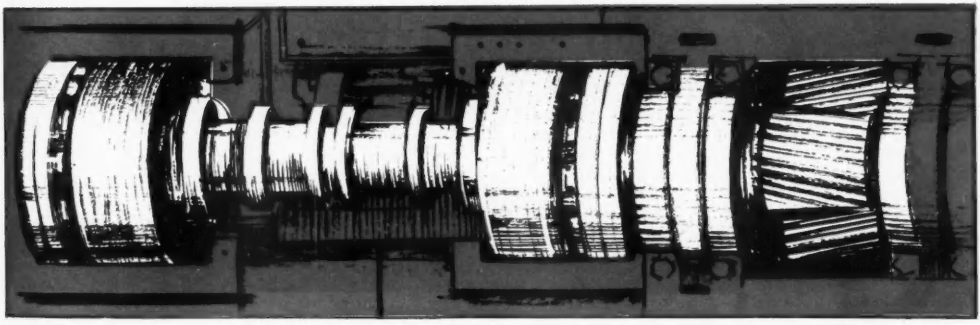
London Office 421, Grand Buildings, Trafalgar Square, W.C.2. 'Phone: WHitehall 5643 and 7963



consult R&M bearing experts



when at the prototype stage



As machines grow more complex and performances increase, the selection of bearings becomes more difficult. It requires specialist knowledge.

In increasing numbers, design and development groups are consulting the Technical Department of Ransome & Marles for guidance. Specification as well as supply is part of the **R&M** service to the engineering industry.

Every enquiry gets equally impartial and confidential consideration. Every project benefits.

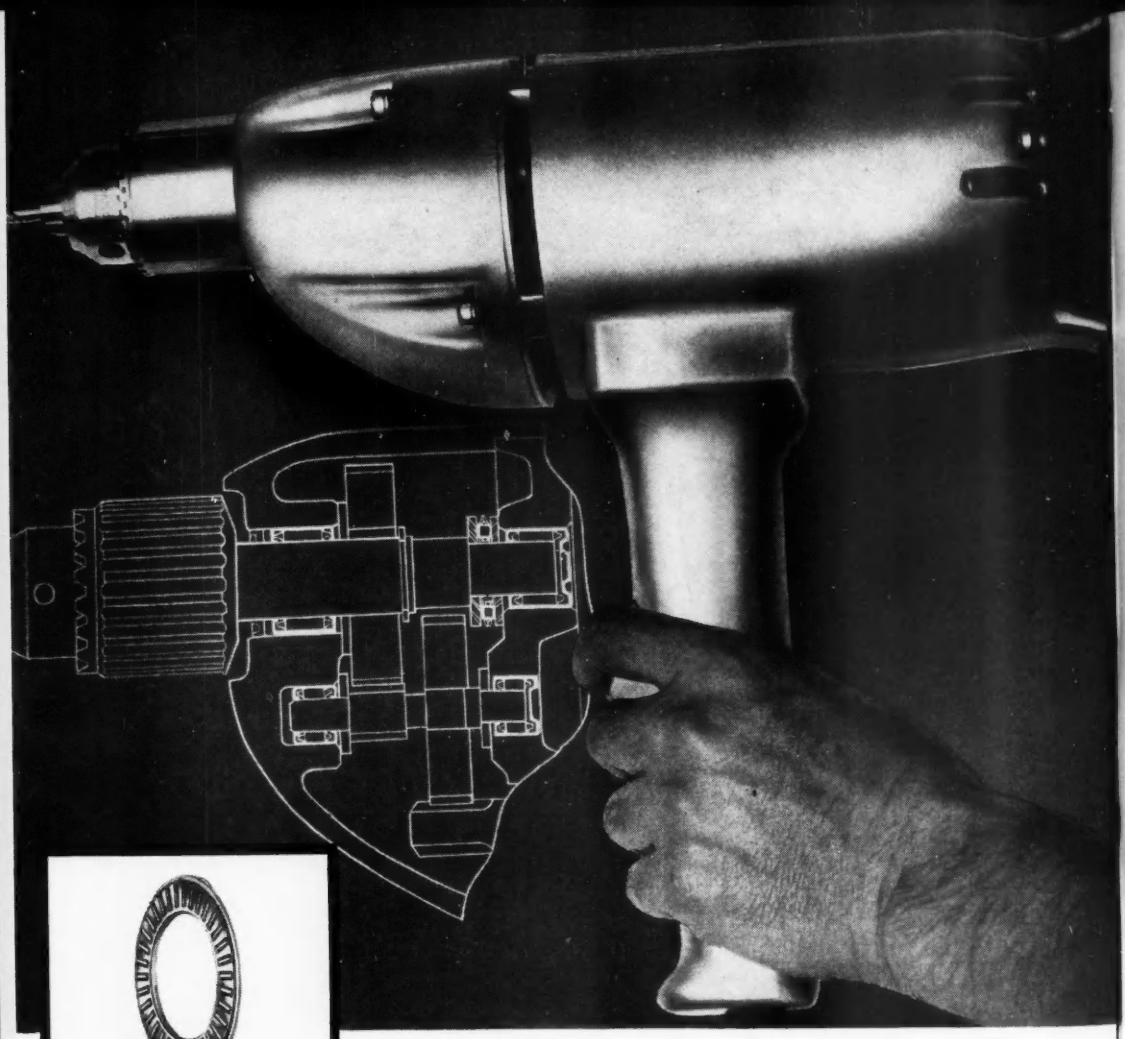
Ransome & Marles produce ball and roller bearings for most applications.

Publication 37 is a comprehensive guide to the full range.

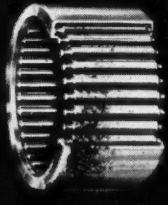
BALL & ROLLER R&M BEARINGS

RANSOME & MARLES BEARING COMPANY LIMITED

NEWARK-ON-TRENT · TELEPHONE 456 · TELEX 37-626 · Branches, offices and agencies throughout the world



For thrust loads
Torrington
Needle Thrust Bearing



For radial loads
Torrington Needle Bearing

B60/C

Made for each other...

Where you want to handle high radial and thrust loads in minimum space, you'll find that Torrington Needle Bearings and Needle Thrust Bearings go together like nuts and bolts. Used together, they contribute to compact design, light weight, maximum capacity and long service life.

Both bearings can operate on hardened and ground adjacent parts or with standard races. Our Bearings Division will be glad to help you make the most of this efficient combination in your thrust and radial load applications.

TORRINGTON BEARINGS

The Torrington Company Ltd. Bearings Division, Torrington Avenue, Coventry
London & Export Office: 7-10 Eldon Street, EC2

Glasgow Office:
50 Wellington Street, C2

This is a PYE

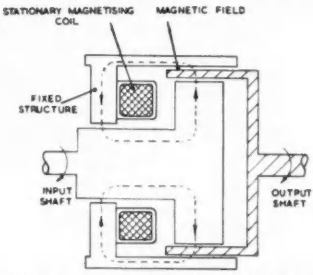
TASC unit
TORQUE AND SPEED CONTROL

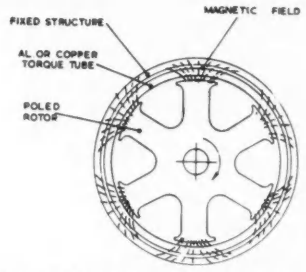
This is what the TASC unit can do

Slash maintenance costs.
Eliminate special precautions against overloads.
Give you local or remote control positively, simply and precisely.
A TASC master (Torque) gives you full control between zero and rated torque.

A TASC master (speed) gives you a 20 : 1 speed range with good regulation, a smooth and fast take up without cogging. Full torque available over the entire speed range. A TASC master (special) can be devised to give you 50 : 1 speed range.

this is what the TASC unit is





The TASC unit is a new application of the Faraday disc principle. It consists of two independently rotating members magnetically linked by the field from a fixed coil. The transmitted torque is proportional to the coil current. It is thus an inherently controlled torque device.

The TASC Unit is unaffected by stall-down on output — no sliprings or brushes — low output inertia — no out-of-balance forces — sealed bearings — sizes from ¼ to 10 h.p.

Find out more about the

TASC unit
TORQUE AND SPEED CONTROL

This coupon with your company letterhead will bring you full technical details and a demonstration at your works if you require it.

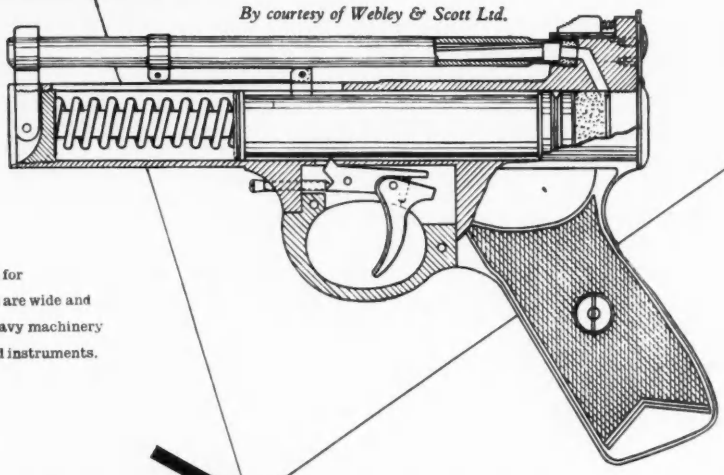
NAME .....
COMPANY .....
ADDRESS .....

PYE ELECTRIC LTD. (LOWESTOFT DIVISION)
Oulton Works, Lowestoft, England
Tel: Lowestoft 1900. Grams: Pylec Lowestoft

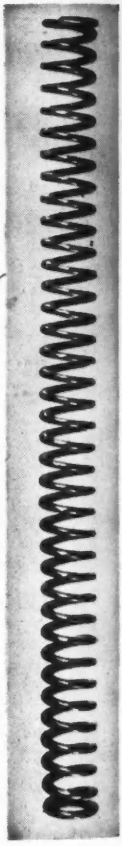
Vital links in controlled movement

A body needs muscles to control
movement in very much the same way as a mechanism needs
springs. These vital links take the stress and strain
of every day rigorous use — nature provides the
muscles . . . SALTER provides the springs.
Two centuries of experience and development
in the manufacture of springs of every type have enabled us to
keep ahead of the ever-changing requirements of industry.

By courtesy of Webley & Scott Ltd.



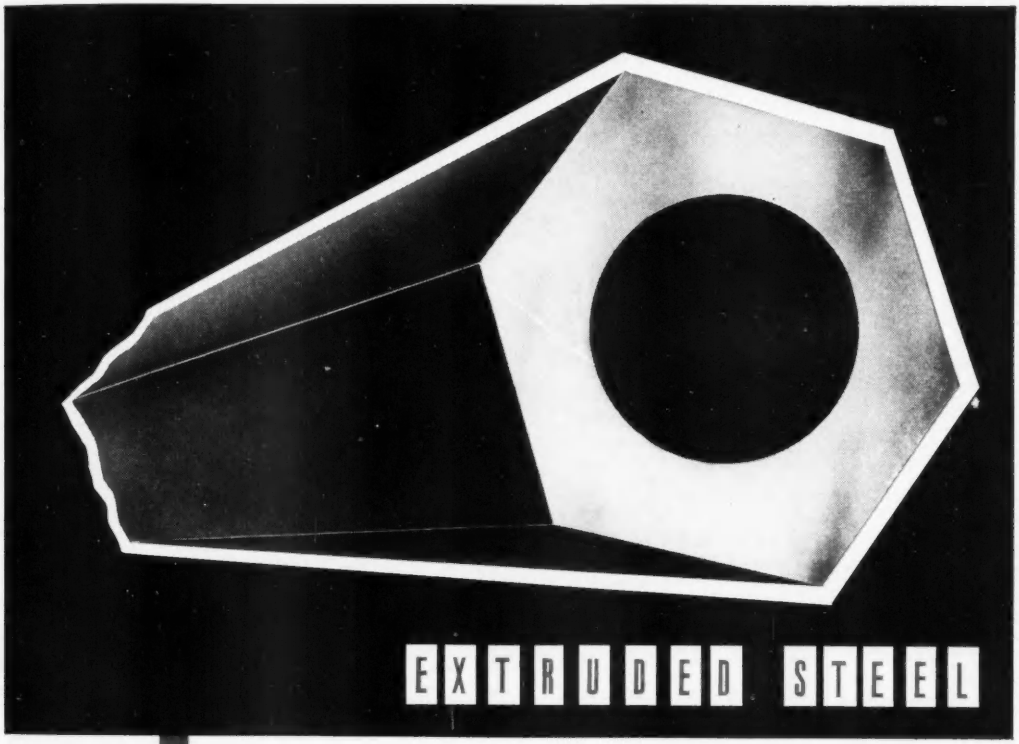
The applications for
SALTER springs are wide and
varied — from heavy machinery
to finely balanced instruments.



For springs with the highest reputation and top performance specify SALTER all-action springs.

SALTER ESTABLISHED 1760

GEO. SALTER & CO. LTD.
WEST BROMWICH
ENGLAND



SECTIONS

Extruded steel sections are produced in most qualities of steel, including carbon and alloy steels, stainless steels and special alloys.

Hundreds of different shapes have already been extruded, ranging from simple angles to most complex shapes. Physical properties are identical with similar rolled sections and extrusions can be supplied in random lengths of 8 feet to 30 feet with dimensional tolerances to suit requirements.

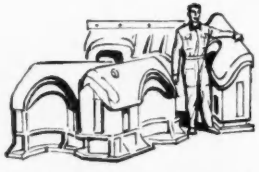
Send for further details of *Osborn* extruded steel sections and take the first step to lower costs by reduction of machining and elimination of scrap.

OSBORN

SAMUEL OSBORN & CO., LIMITED
CLYDE STEEL WORKS, SHEFFIELD
STEELMAKERS · STEELFOUNDERS · ENGINEERS' TOOLMAKERS

A new model?

Take a sales curve and relate it to the shape of your new product. Perhaps dies comes into it. Dies that are precise though large. Dies with a fine finish. Dies soundly constructed for dependability under the stresses of modern mass production press work. Vickers design them, make them, prove them, give satisfaction with them.



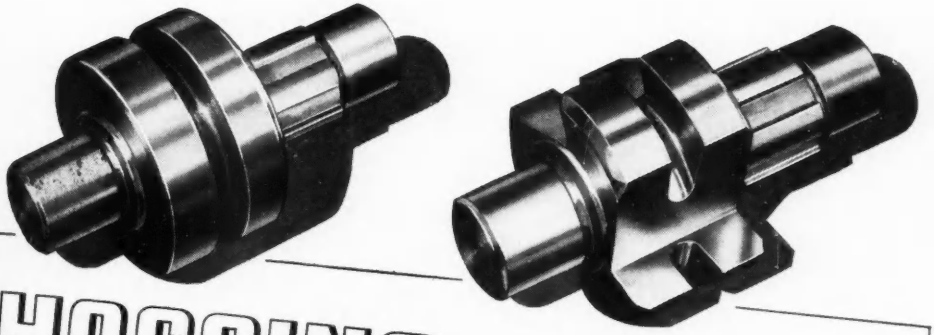
Dies by VICKERS

FOR YOUR NEXT PROJECT . . .
Talk over your requirements with Vickers at the planning stage

Vickers-Armstrongs (Engineers) Limited

DIE DEPARTMENT ELSWICK WORKS NEWCASTLE UPON TYNE 4 PHONE NEWCASTLE 33101

TGA EN408



HOGGING - or Finishing...

CUNLIFFE & GROOM

Horizontals
Do the job Better and Faster

- **AMPLE POWER**
- **WIDE SPEED & FEED RANGE**
- **SIMPLIFIED CONTROLS**

In the well-equipped works of Herbert Morris Ltd. Loughborough, this CUNLIFFE & GROOM horizontal shows to advantage on the milling of wheel shafts.

These machines, with their massive rigidity and ample power, are capable of real 'hogging' or carrying out light finishing with the utmost precision.

We will gladly tell you the full story.

Please write for catalogues.

Works:
BLACKPOLE WORKS · WORCESTER

Telephone No. Worcester 27081 (6 lines)

JAMES ARCHDALE & CO LTD
LEDSAM ST. BIRMINGHAM 16 · *Tel:* EDGbaston 2276
A MEMBER OF THE STAVELEY COAL & IRON CO LTD GROUP

Sole Agents: ALFRED HERBERT · COVENTRY · *Tel:* 89221

FOUR helpful publications

Constant research has ensured that Walpamur Industrial Finishes meet every requirement of modern industry, and these four free publications will help you to make the best possible use of this extensive range.

CATALOGUE OF INDUSTRIAL FINISHES describes the pre-treatment of metal surfaces before painting and gives details of primers, fillers and stoppers, stoving finishes,enamels, nitro cellulose finishes etc.

EPOXY RESIN PAINTS booklet details the complete range of FEROX epoxide resin based paints, including stoving, air drying, and cold cure finishes for many industrial requirements.

SILICONE LEAFLET gives information about the use of silicone in heat resisting and water repellent paints, bonding varnishes, etc.

INDUSTRIAL SHADE CARD shows the complete range of colours available for all types of finishes.

All are obtainable free on request to:

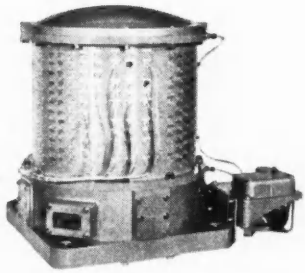
THE WALPAMUR COMPANY LIMITED
DARWEN AND LONDON

Paints, enamels, varnishes and finishes for every industrial need

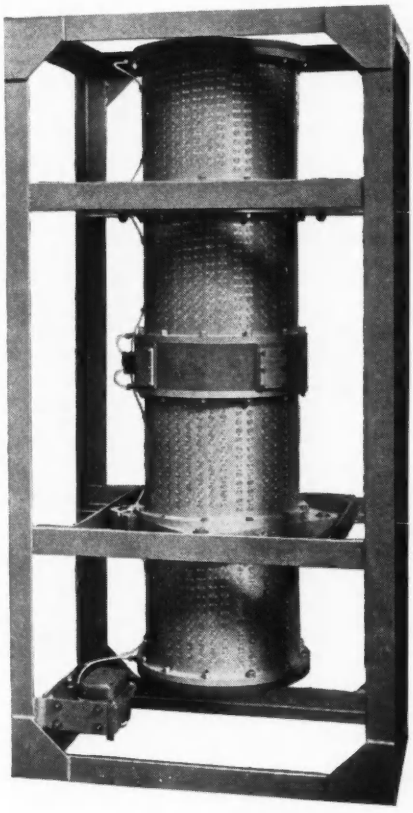
BY APPOINTMENT
TO HER MAJESTY THE QUEEN
MANUFACTURERS OF PAINT
THE WALPAMUR CO LTD
DARWEN . LANCS

MEGABILITY

versus Binary Digititis*



1 megabit to 4 megabits



Magnetic storage drums afford the most economical method of medium-access storage of information.

The new range of Sperry type C Magnetic Storage Drums provides to computer designers and users a flexible range of storage capacity with a "building-block" growth potential, directly related to the increasing demands on the complete system.

SPERRY

Magnetic Storage Drums

SPERRY GYROSCOPE COMPANY LIMITED

Great West Road, Brentford, Middlesex
Telephone: ISLeworth 1241. Telex: 23800

Makers of scientific instruments since 1856

Make an instrumental note . . .

that if you have anything to analyse, to measure, inspect, or survey, the people to help you are Hilger & Watts.

Autocollimators, Block Levels and Clinometers, Circular Division and Angle Measuring Instruments, Dividing Engines, Linear Measuring Machines, Microscopes, Gauge Interferometers, Optical Flats, Angle Gauges, Polygons, Etc., Scales and Circles, Projectors, Analytical Instruments, Surveying Instruments.

HILGER AND WATTS LTD · 98 ST PANCRAS WAY · LONDON · NW1

HILGER & WATTS LTD., DORTMUNDE HORDE, GERMANY

HILGER & WATTS INC., CHICAGO 5, U.S.A

THE

POLYBLOC

TRADE MARK

SYSTEM

for Corrosion Resistant HEAT EXCHANGE Equipment

*

Made from highly inert graphite blocks,
Very robust,
Fully detachable,
Takes advantage of "End Effect" for remarkably
high heat exchange efficiency,
Important anti-fouling effect,
Fuel economy,
Savings in maintenance cost.

*

Equipment constructed on the Polybloc principle
can ideally solve your problems of
**Heat Exchange, Absorption, Evaporation, Concentration,
Condensation, Stripping, etc.**

We shall welcome **your** *enquiries.*

*

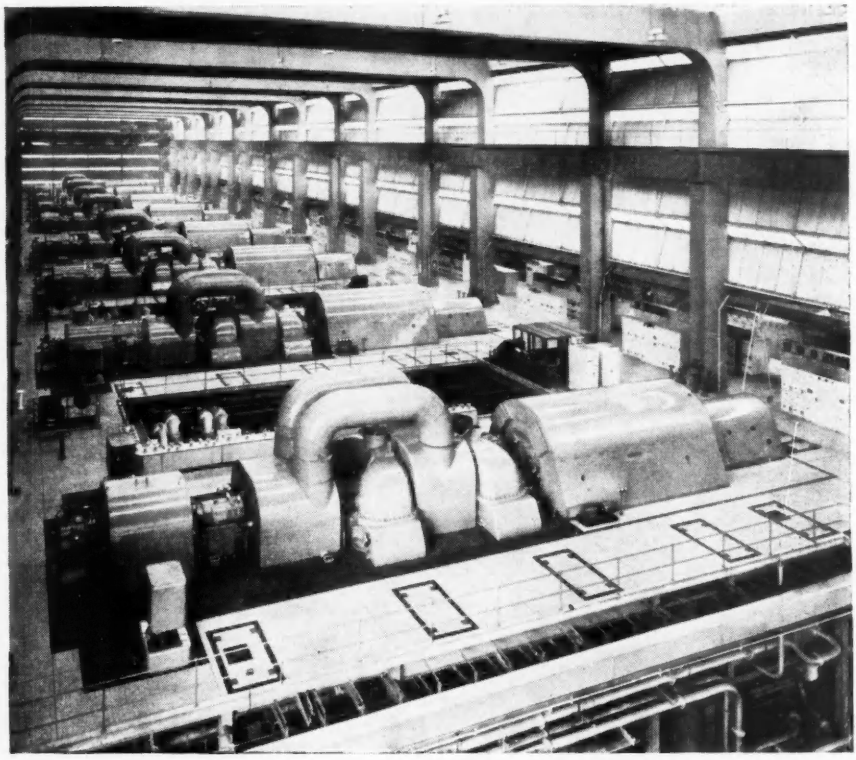
Manufactured and sold in Great Britain by

ROBERT JENKINS & CO. LIMITED

ROTHERHAM · YORKSHIRE

in U.S.A.
The Carbone Corporation, Boonton, N.J., U.S.A.

for the rest of the World
Société le Carbone-Lorraine, 45 Rue des Acacias, Paris (17e), France.



Eight 'English Electric' 60MW, 3,000 r.p.m. hydrogen-cooled turbo-alternator sets at the Marchwood Power Station of the Central Electricity Generating Board. The station also includes 'English Electric' 3·3kV switchgear.

Power generation
Power transmission
Power distribution
Power conversion
Power control
Power utilisation
Power measurement
Power transformation

'ENGLISH ELECTRIC'

Power is our business

THE ENGLISH ELECTRIC COMPANY LIMITED, ENGLISH ELECTRIC HOUSE, STRAND, LONDON, W.C.2

Partners in Progress with NAPIER, MARCONI'S, VULCAN FOUNDRY and ROBERT STEPHENSON & HAWTHORNS in The ENGLISH ELECTRIC Group

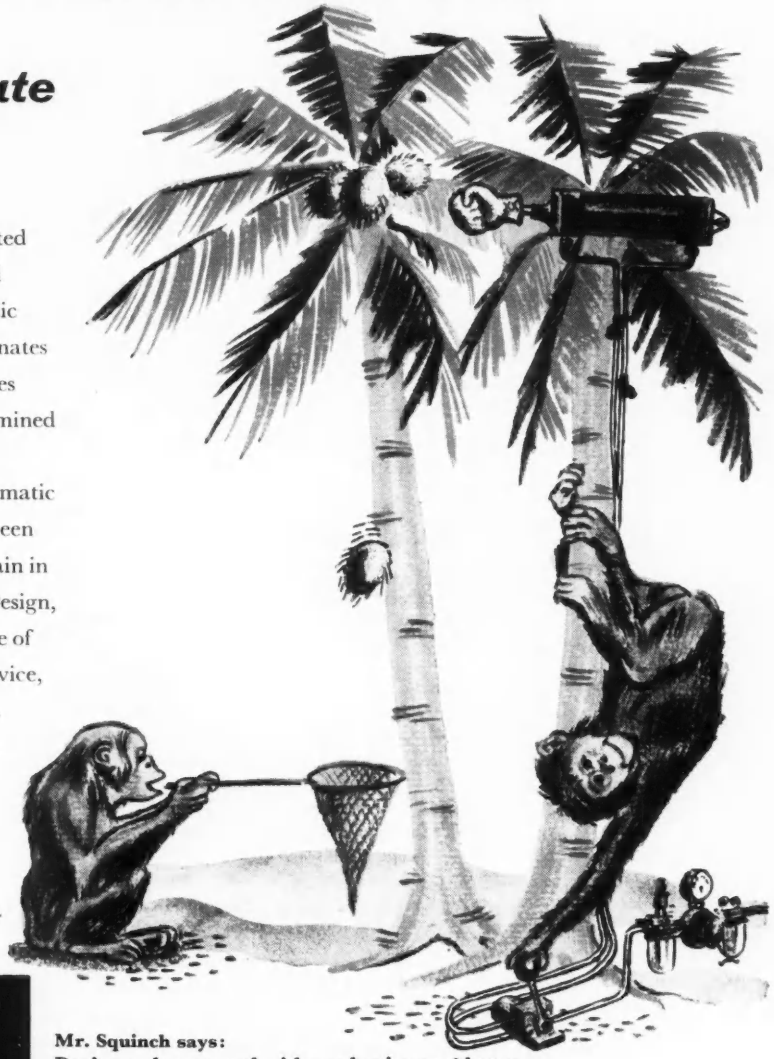
P.85

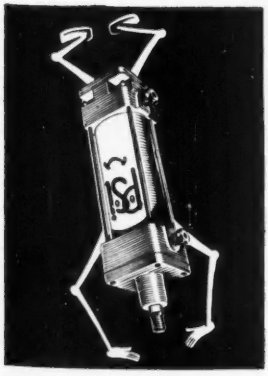
PNEUTOMATION

for accurate control

No matter how complicated the sequence of industrial processes, Lang Pneumatic Control equipment eliminates human error, and operates continuously to predetermined standards of accuracy.
Every item of Lang Pneumatic Control equipment has been proved over and over again in tests and in actual use. Design, workmanship, and choice of materials ensure long service, freedom from trouble . . . and consistent accuracy.

PNEUTOMATION
CANNOT FORGET
PNEUTOMATION—
ENERGY UNDER CONTROL





Mr. Squinch says:
Don't monkey around with production problems: consult Lang Pneumatic.

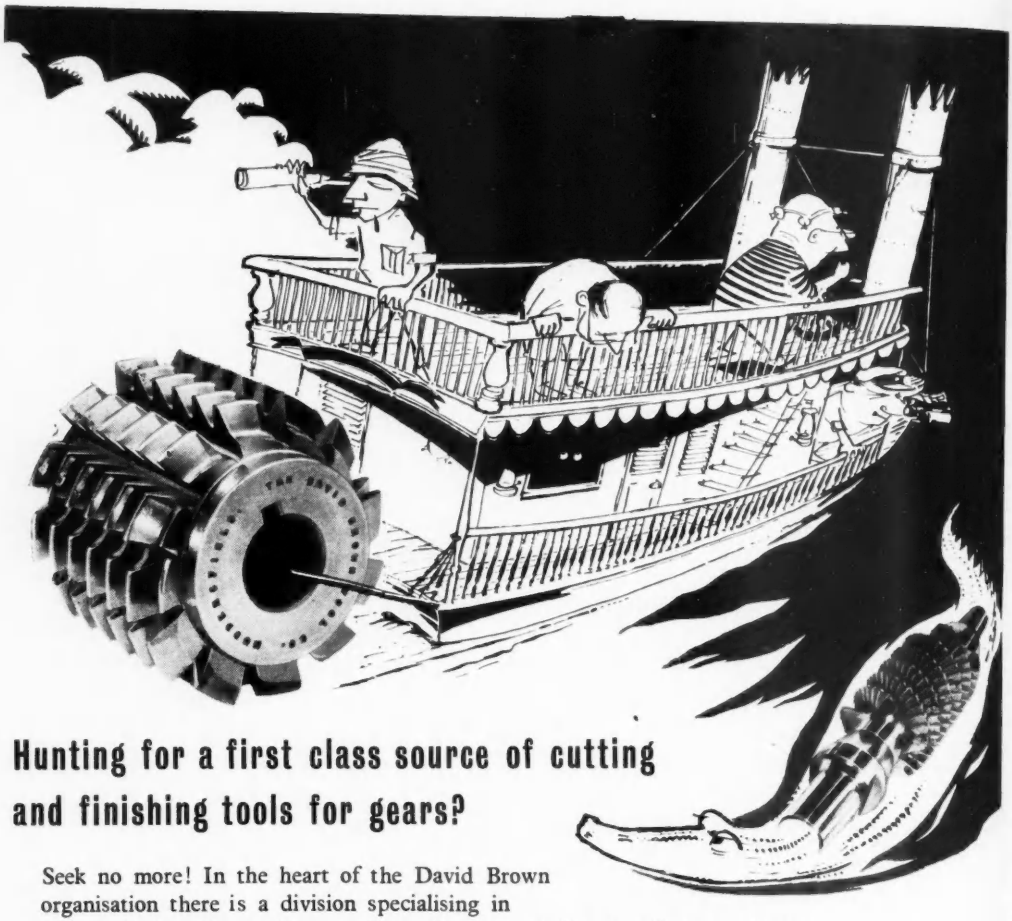
Write to:

Lang Pneumatic Ltd

(ASSOCIATED WITH DESOUTTER BROTHERS [HOLDINGS] LTD)

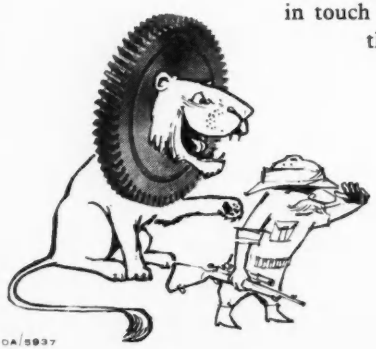
OWEN ROAD · WOLVERHAMPTON

Tel: Wolverhampton 25221-2-3-4
Telex: 33193 P.3642



Hunting for a first class source of cutting and finishing tools for gears?

Seek no more! In the heart of the David Brown organisation there is a division specialising in making Hobs, Shaper Cutters, Rack Cutters and Shaving Cutters—the lot. Since David Brown have been making fine quality gears and the tools for cutting them for one hundred years, it follows that there is a wealth of experience to draw on. So, if you have a gear cutting or finishing problem get in touch with David Brown. You will find their area engineers very willing to help you.



DA/5937

DAVID BROWN

100 YEARS SERVING INDUSTRY 1860-1960

THE DAVID BROWN CORPORATION (SALES) LIMITED

TOOL DIVISION · PARK WORKS · HUDDERSFIELD
TELEPHONE: HUDDERSFIELD 3500

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *COMPACTING METAL POWDERS BY EXPLOSIVES*

Techniques of explosive metal-forming are now being applied to the field of powder metallurgy for blasting the powdered metal into shape. Basically, the set-up includes a die, powdered metal, and an explosive. When the explosive is set off, the pressure thus exerted forces the powder against the die, giving a speedily formed compact. This development has been stimulated by the desire to find a cheaper and easier way of processing metals such as titanium, which are difficult to work in bar form.

Studies have been conducted on various metal powders, including titanium alloys, nickel alloys, stainless steel, tool steel, beryllium, molybdenum, uranium, aluminium alloys, tantalum, and tungsten, with the object of producing high-density, high-quality parts with physical properties comparable with, or better than, those produced in the usual manner, in which powder is mechanically compressed and then sintered. To date, densities of 97% of the theoretical density have been achieved with this method.

One problem originally encountered was the adverse reaction of the explosive gases with the metal powder, and this has led to isolating the metal powder from the actual blast and transmitting the compressive force through an intermediate medium, such as water. Damage to tooling is another problem, because the pressures required for good compacting are in the region where tool fracture occurs. The forming set-up must therefore be arranged to direct and contain the forces of explosion, so that the compressive strength of the tool material determines the amount of pressure that can be applied. The rate of energy released is approximately 25,000 ft-lb/sec, the total required time for moving metal by explosives being measured in micro-seconds.

From *Product Engineering*, U.S.A., September 19, 1960, p. 16.

● *INSTRUMENT FOR MEASURING THE VELOCITY OF SOUND IN LIQUIDS*

A new sound-velocity measuring instrument, originally developed for the measurement of sound in sea-water, is claimed to have many possible industrial applications. With this instrument the velocity of sound is obtained by measuring the time required for a pulse to traverse twice the length of the velocimeter, whose test chamber is bounded by a transmitting and a receiving crystal, the transmitting crystal being driven by a series of pulses, each of 0·05 microsec duration. When a pulse is applied to the transmitting crystal, a wave train is transmitted through the liquid and is reflected back and forth between the two crystals. The repetition frequency of these pulses is adjusted so that a new pulse is initiated each time the reflected wave returns to the transmitting crystal. In this manner, all wave trains move through the liquid in phase. To provide a visual indication of wave superposition, the waves are picked up by the receiving crystal and displayed on an oscilloscope. Thus, the reciprocal of the pulse-repetition frequency represents the time required for the sound waves to travel twice the length of the acoustic path. Sound velocity in the liquid is computed from this time and from the known distance between the crystals.

One industrial application of the velocimeter is in quality control. For instance, where the purity of a sample is important, the measurement of sound velocity will lead to the detection of impurities to within one part in 100,000 by weight when the impurity is in solution. For the bulk production of solutions, the velocimeter, in conjunction with suitable electronic systems, could drive servo-mechanisms for the control of the relative proportions of the constituents. Among other possible applications may be mentioned the use of the velocimeter to identify and evaluate for purity the products from distillation and cracking processes.

From *Electronics*, U.S.A., September 9, 1960, pp. 69–71.

● *FUNDAMENTAL STUDIES OF ULTRASONIC WELDING*

In order to gain an understanding of the fundamental facts involved in ultrasonic welding, studies have been made to determine the mechanism of bonding, the effects of welding variables, and the effects of material factors. After preliminary experiments indicated the importance of the heat generated at the weld interface, apparently from a simple friction reaction, a simple weld joint was used for further studies of the mechanism of bonding. Sphere-to-plate welds, involving a single interface, were made, since such welds permit precise measurements to be made of the phenomena occurring

end doubt about finish

maintain quality through thick and thin with

NASHTON

THICKNESS MEASURING INSTRUMENTS

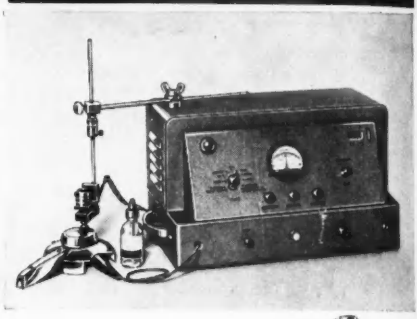
If you are concerned with the quality of any coating on any material, Nash & Thompson can help you. We are specialists in metallurgical and other testing instruments for both laboratory and production. **NASHTON** instruments provide both destructive and non-destructive methods of testing the thickness of a very wide range of surface finishes. Each method has its advantages and limitations but Nash & Thompson as suppliers of the most comprehensive range of thickness measuring instruments in Britain will give you really unbiased advice to enable you to select the most suitable instrument for your particular application.

1. BNF Plating Gauge
For non-destructive measurement of nickel on steel, or brass, and zinc based die castings. Range 0.002 in.—0.00025 in., accuracy ± 0.0001 in. Also used as metal sorter for differentiating between similar metals.
Basic price £238

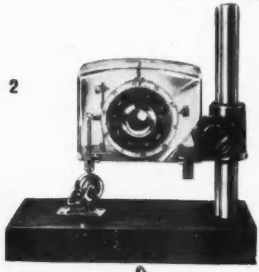
2. Magne Gage Thickness Tester
For simple and quick non-destructive measurement of wide variety of coatings on magnetic basis metals. Accuracy ±10%.
Basic price £117

3. Kocour Thickness Tester
For destructive measurement of an exceptionally wide range of coatings and basis metals. Coulometric principle—small area of plating is stripped with standard solutions, a mechanical read-out counter stopping when all coating is removed. Basic price £246

4. Accuratest Thickness Tester
For non-destructive measurement of non-conducting coatings on non-ferrous bases. Range 0.0001 in. — 0.005 in. Accuracy ±10%.
Basic price £133

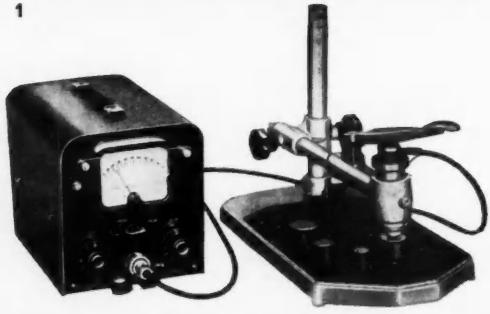


3

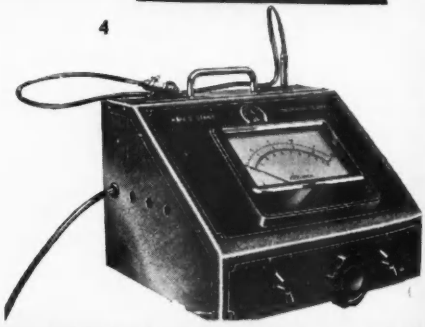


2

1



4



Please write for technical data stating your problems and requirements

Nash and Thompson

Limited

Hook Rise South, Tolworth, Surbiton, Surrey
Telephone: ELMbridge 5252

during welding. Many of the data obtained so far have indicated that bonding is due to the formation of a thin molten film at the interface. However, since no definite proof of this mechanism was obtained, there remains the possibility of solid-state bonding.

A study of the literature regarding friction has aided in the derivation of some equations which may be helpful in mathematically expressing the important factors involved in ultrasonic welding conditions. However, additional work is needed to integrate into these equations the continuing changes in properties and contact area which occur during welding.

Studies were also made to determine the effects of welding conditions on the properties of ultrasonic spot welds, aluminium being used in most of these studies. The strength of aluminium ultrasonic spot welds increases in a nearly linear manner with increased welding-tip displacement, rising rapidly with increases in welding time to a maximum value in the first few seconds, and then remaining constant. Increased clamping pressure, other factors being constant, increases weld strength linearly to a maximum value, at which the strength then levels off or even becomes less when the clamping pressure is further increased. No differences in weld properties were noted for aluminium welds made with rough or smooth weld tips of 3 or 6 in. radius. The strength of welds in aluminium was not affected by removing the oxide film before welding.

From *Welding Journal*, U.S.A., August 1960, pp. 331s–341s.

● *VIBRATORY COLD-WELDING*

Existing techniques of fusion welding and pressure welding suffer from certain serious disadvantages. Thus, for instance, fusion welding is characterized by a cast nugget structure, with the weld zone markedly changed by the application of heat. Pressure welding, on the other hand, involves the use of high clamping loads, resulting in excessive deformation, and is not applicable to all metals.

These disadvantages are claimed to have been overcome in a vibratory cold-welding process which appears to be suitable for a wide variety of metals and alloys, e.g., aluminium, titanium, copper, brass, and iron and its alloys, as well as for products made of sintered materials, such as aluminium powder. In this new process, welding is carried out under a clamping pressure sufficient to hold the metals being welded in firm contact, without any appreciable deformation; vibratory energy is then introduced by magnetostrictive transducers, optimum frequencies being in the range from 5000 to 40,000 cps. The time required to produce a weld varies from 0·001 to 6 sec. Preferably, the process is carried out by operating at resonant frequency, particularly where thicker metal sheets are to be welded. However, some deviation from the design resonant frequency may be tolerated, especially in the welding of relatively thin metal sheets. The welding process may be applied to metals which have not undergone the preliminary treatment required for other welding processes. For example, aluminium sheets have been welded in the "as-received" condition.

It is an essential feature of the process that the vibrations must possess a component which is tangential or lateral with respect to the bond to be produced. For example, where two sheets are to be welded together, vibrations parallel with the surface of the sheets must be exerted. The mechanism of operation of the welding process is not fully understood, but it is believed that the tangential or lateral vibratory component disrupts the interfacial geometry and more or less destroys it. Thus, nascent surfaces are created and made to contact each other, leading to their welding together.

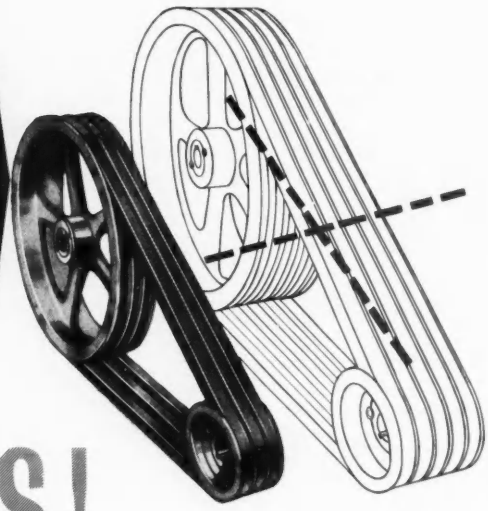
From *Brit. Pat. Spec.* 837,869. Aeroprojects Inc., West Chester, Pa., U.S.A.

● *THERMOPLASTIC IMAGE-RECORDING AND PROJECTION SYSTEM*

Although the thermoplastic image-recording system recently developed in the U.S.A. is still in the development stage, the principle on which it is based is by no means new and, in fact, stems from that used in the Gretner "Eidophor" large-screen television system invented in Switzerland about twenty years ago. In the Gretner system, an extremely fine beam of electrons, modulated by the information to be reproduced, is directed against a thin film of oil on a mirror by means of an electron gun, with the result that the oil becomes charged and a pattern of electrons, in the form of wrinkles or dimples, is "written" on its surface. This pattern is then projected by a modified optical system onto a screen, reproducing in black-and-white or in colour a clear and brilliant image, the size of which depends theoretically only on the intensity of the projection lamp used.

In essence, the thermoplastic recording system is similar, except that, in place of an oiled mirror and a "temporary" image, a plastic tape is used to produce a permanent image, if required. The pattern of electrons is recorded on the surface of the tape, which is then temporarily softened by the application of heat. As the surface softens, it is deformed or wrinkled by the attraction between the negative charge pattern on the surface and the relatively positive base, after which it is allowed to cool and harden, freezing the wrinkles on the surface. The entire process can be completed in less than 0·01 sec. The tape uses a base similar to

CROFTS ULTIVEE ROPE DRIVES!



minimum space—maximum power capacity

CROFTS ULTIVEE ROPE DRIVES HAVE ALL THESE FEATURES AND ADVANTAGES . . .

Ultivee Drives are offered as an addition to our range of V-Pulleys and "Supror" Ropes—the existing range of "Supror" V-Ropes and/or pulleys is still available as required

- Compared with orthodox V-Rope Drives Crofts ULTIVEE Rope-drives transmit more power in less space, reducing the number of ropes as much as 40 per cent.
- Permit smaller pulley diameters and face widths with shorter centre distances—the weight of the whole drive is thus reduced.
- A standardised range of pulleys is available either taper bored for Crofts Patent Taper-Flushbushes or Parallel bored with keyway.
- Only three sections of ropes in a large range of lengths are used, the two smaller sections covering the majority of industrial requirements.
- Installation and replacement costs materially reduced.

Write today for further details!

For EX-STOCK service in BIRMINGHAM ring ASTon Cross 4471/2

Crofts
REGD TRADE MARK

CROFTS (ENGINEERS) LIMITED
POWER TRANSMISSION ENGINEERS
THORNBURY BRADFORD 3, YORKSHIRE
Telephone: 65251 (20 lines) *Telegrams: "Crofters Bradford Telex"* *Telex 51186*
WORLD WIDE REPRESENTATION

that of standard motion-picture film, with a transparent conducting coating on the base and a thin coating of thermoplastic material on the surface, the wrinkles being formed only on the top coating. The tape can be erased simply by heating it slightly, the plastic being smoothed by surface tension, after which it can be re-used.

The system used to project images from the tape is basically similar to that used in the "Eidophor", except that light is transmitted through the film, instead of being reflected from the mirror. As in the "Eidophor", the new system uses two sets of bars, the first of which is located between the light source and condensing lens, so as to convert the incoming light into a series of lines which are then focused onto the second set of bars, located between the condensing and projection lenses. The relative disposition of the bars is such that, with a clear tape, the lines of light from the first set of bars are blocked by the second set of bars, so that no light reaches the screen, which therefore appears dark. However, any ripples or wrinkles on the tape cause the incoming light to scatter, so that some of it passes through the bars and is focused as dots on the screen. In effect, then, the bar system acts as a shutter, allowing light to pass only where there is a ripple on the tape, producing a picture on the screen.

As in the case of the "Eidophor" projector, the new thermoplastic recording system can be adapted for projection in colour. In addition, quite apart from the projection of images, it can be used to store on the tape information which can be read out as an electrical signal generated by photo-electric devices. In fact, the system can record and store electrical signals at rates in excess of 50,000,000 cps, and can concentrate at least 100 times as much information in a given space as can magnetic recording.

From *General Electric Research Laboratory*, Schenectady, N.Y., U.S.A.

● *BROACHING TOOL WITH REPLACEABLE CUTTING ELEMENTS*

Since, normally, one pass of the broaching tool is sufficient to finish-broach a surface, the cutting-surface area of the broach tool must be commensurate with the area of the surface to be broached. As the size of surfaces to be broached is nowadays continually increasing, larger and heavier broaching machines are required to handle and move larger broaching tools. If a surface is to be broached in one pass, it is recognized that the width of the broaching tool must at least be equal to the width of the surface, and that the length of the broaching tool is a function of the total chip thickness to be removed. This means that the total area of the broaching tool could be very much larger than the area of the surface being broached. The usual practice is to provide a broaching tool with a large number of individual broaching teeth, each of which has a limited capacity in the amount of chip material that it can remove. However, the sharpening of large broaching tools, with their large number of teeth, is very expensive, and it would therefore be desirable to find a means of simplifying sharpening operations and to make it possible to repair broaching tools without removing them from the machine when individual cutting teeth become broken.

To overcome these difficulties, a recent patent refers to a new broaching tool, so designed as to have a number of groups of detachable bits with cutting edges. The bits are arranged transversely and longitudinally, the bits of each group producing a single cut, and the groups are progressively elevated to produce successive cuts of progressively greater depth. A number of bit-carriers with recesses to receive one group of bits is provided. The recesses have walls to position the bits automatically at the desired rake angle, the cutting edges being located above the surface of the carrier by a predetermined amount. Either a single bit can be renewed from a bit-carrier, or a single bit-carrier can be removed to remove a group of bits, as required. Also, the bits can be turned quickly and accurately located and clamped, so as to provide a new cutting surface for the broach, without having to remove the entire tool from the machine.

From *Brit. Pat. Spec.* 842, 250.
The Cincinnati Milling Machine Co., U.S.A.

● *IMPROVED METHOD OF COATING FERROUS MATERIALS WITH ALUMINIUM*

Various methods of coating ferrous materials with aluminium in such a way that the coating is effectively fused to the surface are known. Thus, in one such process, used for coating the internal walls of steel pipes, alumium is sprayed onto the surface, and the pipe is then subjected to heat treatment to fuse the coating into a non-porous skin and to bond it securely to the pipe. However, this process gives rise to certain difficulties, mainly in connection with the sealers used to prevent oxidation of the ferrous metal during heat treatment, inasmuch as these sealers are vaporized during heat treatment and create problems of venting the resulting vapours.

To overcome these difficulties, a recently patented process is designed to produce improved coatings of aluminium and also to provide a simple solution to the problem of oxidation during heat treatment. In the case of the internal walls of steel pipes, the inside of the pipe is first thoroughly cleaned and somewhat roughened, after which the aluminium coating is applied by means of a spray gun. The thickness of the coating can be varied as desired, a

Concentration

Few more perfect examples of concentration—the co-ordination of eye, mechanical timing and innate personal skill—will be found than the art of the craftsman at the hammer. Father to son, down the generations, this "know-how" is abundantly in evidence at Firth Brown

FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS. FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

thickness of about 0·003 to 0·015 in. generally being suitable. The pipe is then filled with an inert gas, such as nitrogen, argon, or krypton, to displace all air or oxygen, and its ends are sealed. The subsequent heat treatment fuses the aluminium coating into an impervious skin or lining, effectively bonded to the pipe wall. The heat-treatment temperature is generally in the range between 1250 and 1450°F, with the time of treatment inversely proportional to the temperature. Treatment at 1300°F for 30 min is considered satisfactory in most cases, while treatment of a 0·015-in. coating for from 10 to 15 min at 1350°F gives excellent results. The aluminium lining is, in effect, fused to the ferrous metal, even though the heat-treatment is somewhat below the melting temperature of the base metal. The depth of the aluminium-ferrous metal fusion is about 0·003 in. with a sprayed-on layer of 0·015 in., so that the fused aluminium coating is practically inseparably bonded to the base metal; at the same time, an unadulterated coating of aluminium remains on the surface, effectively shielding it from corrosion.

From *Brit. Pat. Spec.* 843,578.
Chicago Metallizing Corporation, Chicago, Ill., U.S.A.

● ***RESEARCH ENGINE WITH QUARTZ PISTON***

A quartz-piston engine has been developed which permits an unobstructed view of the combustion processes occurring in overhead-valve combustion chambers with compression ratios as high as 10·7 : 1. In this engine, which is of normal overhead-valve construction, but has an elongated piston and a piston crown made of clear, fused quartz, the combustion process is viewed through a slot in the side of the piston by looking at the reflection in a canted mirror held stationary inside the piston. The top and bottom surfaces of the quartz are flat and are polished to provide a transparent piston crown, the final dimensions of the quartz being determined by simultaneous consideration of optical limitations, bonding-area requirements, requisite metal wall thickness, and quartz weight. The upper piston section serves three functions, i.e., to provide support for the quartz crown, to seal the combustion chamber from the mirror region by providing two compression rings and one oil control ring, and to provide room for mounting the stationary mirror inside the piston.

The cylinder head is of standard overhead-valve design and, since a flat top is furnished on the quartz piston crown, the combustion chamber formed by the piston and cylinder head can be of standard automotive design, so that the compression ratio is limited only by the usual problems of valve and spark-plug location. Various cylinder heads are available, providing combustion chambers with compression ratios from 4·9 : 1 to 10·7 : 1. Provision is made to admit external light to the combustion chamber by sandwiching a Pyrex disc of the same dimensions as those of the gasket between the cylinder and the head. It is claimed that this new engine makes it possible to study combustion phenomena under engine operating conditions.

From *SAE Journal*, U.S.A.,
July 1960, pp. 32-34.

● ***LEAD MONOXIDE AS A LOW-FRICTION COATING FOR HIGH-TEMPERATURE BEARINGS***

A new bearing development utilizes the lubricating properties of lead monoxide to provide a low-friction coating which can operate over a temperature range from room temperature to 1250°F. It is stated that effective lead monoxide coatings of several compositions have been applied with success, in the manner of porcelain enamels, to certain stainless steels and Inconel X. One such coating, combining excellent adherence with low friction properties, contains about 5% silicon dioxide and 5% iron oxide absorbed from the steel during the firing process. The coatings are applied as a dry powder or are sprayed on as a water slurry, and are then fired in the range from 1650 to 1800°F. Such films provide lower coefficients of friction at temperatures exceeding 600°F than commercial resin-bonded molybdenum disulphide coatings.

Unlike conventional lubricating systems, which give best results when low surface temperatures at the bearing surface are maintained, the new coatings lubricate best under conditions tending to promote high bearing-surface temperatures, i.e., high ambient temperatures and high sliding velocities. For sliding velocities in the range from 2400 to 10,000 fpm, coefficients of friction ranging from 0·05 to 0·08 have been obtained for temperatures up to 1200°F. This performance is probably explained by the formation of a glazed or vitreous surface promoted by the lead monoxide in the zone of sliding. Sliding then takes place by plastic or viscous shear, rather than by shear along crystal planes. The endurance life of these coatings appears, however, to be sensitive to temperature, with a maximum at 1000°F.

From *Materials in Design Engineering*, U.S.A.,
September 1960, p. 9.

Readers desiring further information on any developments reported in THE BLUE PAGES are invited to write to the Editor. Copies of the full specifications of any British patents mentioned, which are published by courtesy of H.M. Stationery Office, should be obtained from the Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2. Price 3s. 6d. each.

ANNOUNCEMENT
Laycock Engineering Limited announce that Layrub Flexible Couplings are now available for general industrial use.
As the original designers and producers of this coupling, we shall be pleased to offer full advice for its use in every form of industrial transmission however large—however small.
The Layrub Coupling needs no lubrication and it provides vibrationless, trouble-free, full transmission of power in all conditions.
LAYCOCK ENGINEERING LTD
(Dept ED)
Victoria Works • Millhouses • SHEFFIELD 8
Member of the Birfield Group

LAYRUB

flexible couplings for

INDUSTRY

THE ENGINEERS' DIGEST
A World Review of DESIGN & PRODUCTION — RESEARCH & DEVELOPMENT
VOL. XXI No. 11 NOVEMBER, 1960

The Mechanical Restraint of Shrinkage in Castings made in Metallic Moulds

By V. N. RAZUMOV
From *Liteinoye Proizvodstvo*, Russia,
No. 8, 1960,
pp. 36-40, 11 illustrations.

MECHANICAL restraint of shrinkage is increased when shaped components are manufactured by chill-casting methods, and this article is concerned with the results of a study made into the mechanical restraint of shrinkage in castings produced in metallic moulds, based on the ideas put forward by Spasskyi[1] and Krivoshiev[2].

Krivoshiev's design for metal moulds for cylindrical bodies is based on the idea that the casting moves all over to the centre of its datum surface during the process of shrinkage. It is therefore supposed that, if the face of the mould is also directed to the centre of the datum surface, the casting will then slip along this face during shrinkage and that this shrinkage will undergo no restraint. However, on this hypothesis, two quite different physical processes have been prematurely combined, i.e., the "drawing together" of the metal particles of the casting on cooling and the subsidence of the casting under the force of gravity. Moreover, points of the casting can only possibly move to the mid-point on shrinkage under certain ideal conditions, which Krivoshiev does not discuss. The effect of the force of gravity on the formation of cracks when the casting sticks in the mould is well known to foundrymen and can be calculated. Shrinkage movement (drawing together) across the casting under the action of intermolecular forces can only occur in the direction of the mid-point when shrinkage begins simultaneously at every point on the face of the casting, when the rate of shrinkage is the same all over, and when there is no restraint on the process of shrinkage. Under such ideal conditions, it is obvious that all points on the casting can only move towards the geometric centre.

Ideal shrinkage conditions are never realized in practice, points on the casting usually moving towards a region of central points that are some distance away from the geometric mid-point of the casting. However, one central point can in many cases be substituted for this field with sufficient accuracy for practical purposes. Consequently, in producing the design equation, it is sufficient to consider the ideal case of shrinkage, as this is the simplest.

If the normal standard procedure is followed and the projection of the casting and the movement of its points on shrinkage are studied, instead of the volumetric picture, the projection of the shrinkage movement ε_i of the points i of the casting can be expressed as

$$\varepsilon_i = \alpha R_i \triangle t \quad .. \quad .. \quad .. \quad .. \quad (1)$$

where α is the coefficient of linear expansion, R_i the distance between point i of the projection of the casting and the projection of the geometric centre c (Fig. 1), and $\triangle t$ the temperature drop during the process of shrinkage.

In order to portray the dependence of the rise of mechanical restraint during shrinkage on the geometry of the casting more graphically, a study must be made of the shrinkage movement of the casting-plane projection, as expressed by the straight line bm, at a distance R_n from the projection of the geometric centre c in Fig. 1. For point n on this line,

$$\varepsilon_n = \alpha R_n \triangle t \quad .. \quad .. \quad .. \quad .. \quad (2)$$

For another point b on this line,

$$\varepsilon_b = \alpha R_b \triangle t \quad .. \quad .. \quad .. \quad .. \quad (3)$$

The point b_1 to which b shrinks is a distance b_1q from the line bm, and, because triangles cnb and b_1qb are similar, this distance can be expressed by definite quantities, and it can be shown that

$$b_1q = \varepsilon_n = nn_1 \quad .. \quad .. \quad .. \quad .. \quad (4)$$

It is obvious that eq. (4) is applicable to any point on the straight line. Consequently, the original line is parallel to the line after shrinkage under ideal conditions. Thus, the straight-line projection of the casting is shifted to a parallel position on shrinkage. The amount of the displacement depends on the amount of shrinkage movement of point n at the intersection of this line with a perpendicular dropped onto it from the projection of the geometric centre. This lateral shift of the faces of the casting gives rise to air gaps between the sides of the mould and the casting, or to the restraint on shrinkage of the casting by the walls of the cores.

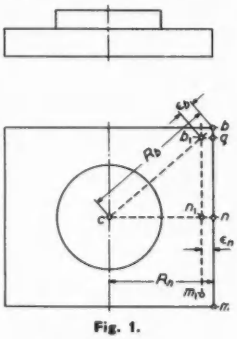


Fig. 1.

Eq. (2), giving the amount of lateral displacement on shrinkage, is applicable to any projection of the straight or curved surface of the casting, if the amount of lateral displacement ε_n is expressed by the amount of shrinkage movement at any point i on that surface. In this case, it is necessary to replace the curved projection at point i by a tangent to this curve, as shown in Fig. 2, from which

$$\varepsilon_n = \varepsilon_i \sin \varphi_i \quad .. \quad .. \quad .. \quad .. \quad (5)$$

where ε_i is the shrinkage movement of point i on the

projection of the casting towards the projection of its geometric centre c, and φ_i is the angle formed at the point by the line connecting the point in question to the projection of the casting centre and the tangent to the projection of the surface of the casting at point i.

The use of eq. (5) makes it possible to calculate the amount of lateral shrinkage displacement of the projection of any casting face at any point. It is therefore the fundamental design equation linking the amount of mechanical restraint on shrinkage, or the size of the air gap, with the geometry of the casting under ideal shrinkage conditions.

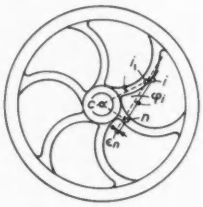


Fig. 2.

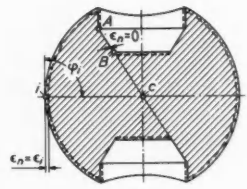


Fig. 3.

If it is assumed that the plane of the casting is continued through the geometric centre, as indicated by line AB in Fig. 3, then $\varphi_i = \text{const.} = 0$, and, from this equation, $\varepsilon_n = 0$. The implication is that this case corresponds to Krivoshiev's formula when there is no lateral displacement of the surface of the casting during shrinkage; consequently, if the mould keeps the same dimensions, the plane of the casting will slip along the surface of the mould without forming gaps and without experiencing shrinkage restraint. This case is called shrinkage with zero lateral displacement.

A second extreme case will occur in the shrinkage of a casting with a spherical surface with the projection of the circumference (Fig. 3). Here $\varphi_i = \text{const.} = 90^\circ$ and consequently $\varepsilon_n = \varepsilon_i$, so that lateral displacement is a maximum all over the surface of the casting. There is the greatest possible gap between the casting and the sides of the mould or, in the case of a spherical core inside the casting, the greatest possible shrinkage restraint takes place. This case is called shrinkage with 100% lateral displacement. It is pertinent to remark that a simple practical rule can be deduced for determining whether mechanical shrinkage restraint will occur, i.e., if the line connecting the point of the projection of the surface of the casting to the projection of its midpoint only intersects the body of the casting, no shrinkage restraint will occur, but if it also intersects the mould, then there will be mechanical shrinkage restraint.

The amount of mechanical shrinkage restraint obviously depends on the dimensions of the casting and the percentage of lateral displacement. The amount of lateral displacement will be constant only if φ_i is a constant. Thus, if $\varphi_i = \text{const.} = 15^\circ$, then $\varepsilon_n \approx 0{\cdot}25\ \varepsilon_i$ and on shrinkage there will be 25% lateral displacement all along the projection of the casting surface. All flat surfaces of the castings are represented by straight-line projections and, if these do not intersect the projection of the geometric centre of the casting, they have a variable angle φ_i. It can easily be shown that the closer are the points of these lines to the centre of the casting, the greater is the angle φ_i and, consequently, the greater, generally speaking, is the amount of lateral displacement. A very important practical conclusion is that in design calculations it is enough to check that those points of the casting surface which come closest to the projection of the casting centre will also experience the greatest shrinkage restraint.

So far changes in the dimensions of the mould have not been taken into account, and this is not permissible. While it is true that a change in the dimensions of the casting, even if for a certain ideal case, can be treated mathematically, a change in the dimensions of the mould cannot as yet be so treated, since such a change depends on many unknown factors and, in particular, on the relationship between the thickness of the casting and that of the mould and on the amount of lateral displacement of the adjacent faces of the casting. In studying mechanical shrinkage restraint, some investigators[1] have discarded the effect of the lateral displacement of the casting surfaces on changes in the dimensions of the mould, so that their account of the process is incomplete.

In the present research, the effect of a dimensional change of the mould on mechanical shrinkage restraint has been checked experimentally for various degrees of displacement of the casting faces. In order to perform these experiments, special metallic moulds were produced in which casting surfaces with 0, 25, 50, 75 and 100% lateral displacement were produced by metallic cores, the walls of the moulds and cores being 30 mm thick, and the castings 50 to 60 mm thick. The temperature of the cores and castings was measured by thermocouples, and special equipment was devised to determine the expansion and contraction of the cores. Although the experiments did not cover every practical case of interaction between the castings and metal moulds, the results reveal the essence of the process of mechanical restraint on shrinkage.

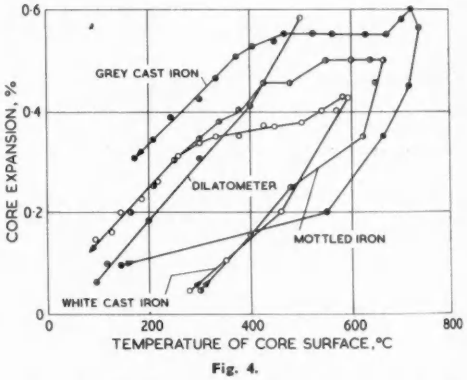


Fig. 4.

It was established that expansion and contraction of the metallic cores are very different from the dimensional changes in slowly heated and cooled metal. The process of change in the core dimensions of various materials, as a function of temperature, is shown in Fig. 4. At the start, when the surface of the core is sharply heated by the liquid metal, its expansion is restrained by the internal (as yet unheated) layers, which are subjected to tension by the hot layers. If the core is heated sufficiently, it will continue expanding at an ever-increasing rate, and the internal tensions are removed at the same time; however, when the casting exhibits elastic resistance, this expansion fails to attain the value corresponding to the degree of heating of the core, and the whole core is elastically compressed by the casting. There is no further change in the dimensions of the compressed core until its

dimensions come into correspondence with the degree of heating during cooling, when the elastic deformations of compression are removed. Further cooling of the core (together with the casting) is accompanied by contraction. Owing to residual expansion, this contraction is not the same as that obtained in slow heating and cooling.

It is also a remarkable fact that a single system is created by the close contact between the core and casting. At the start, these two parts of the system have different temperatures, but, after intensive heat exchange, the system is at the same temperature throughout, and cooling takes place as if in a single body. There is, however, a great difference in temperature between the core and casting if they are separated by a gap.

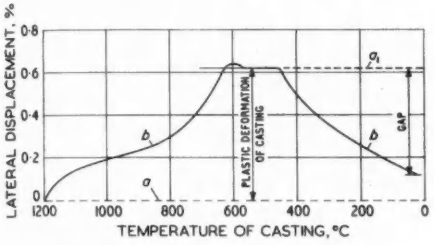


Fig. 5.

In the expansion and contraction of metallic cores, the shift in their surfaces is the same as in castings, i.e., to or from their geometric centre. Since the geometric centre of the core is seldom the same as that of the casting, the percentage lateral displacement of the core and casting surfaces is not the same. In these experiments, it was considered justifiable to assume as a first approximation that the lateral displacement and expansion of the core surfaces were the same. On this simplifying assumption, the interaction between the castings and metallic cores can be analysed from the moment the casting is poured for different amounts of lateral displacement of its surfaces. For this purpose, lateral displacement is plotted as a function of temperature.

If there were no lateral displacement of the surfaces of the casting and no core effect, there would be no movement along the lateral-displacement co-ordinate. However, the surface of the core does shift when heated and displaces the surface of the still plastic casting along with it, as shown by the rising branch of curve *b* in Fig. 5. When the casting is changed into the elastic state, however, the lateral displacement of the core face is restrained, and reverse displacement of the faces of the core begins on cooling, as shown by the falling branch of curve *b*. From this moment on, a gap appears between the plastically deformed casting and the core, since there is no lateral displacement of the faces of the casting at this moment (curve a_1). When cooling is finished, the size of the casting, defined by the core, is larger than it was to start with (roughly 0·6%), and the gap between the casting and the core is considerable. It is obvious that heating of the core and its expansion will be considerably less if the walls of the castings are thinner; as a result, the plastic deformation of the casting will be less, and the gap between the core and casting will be less than that obtained in this particular experiment.

With a 50% lateral displacement, the lateral displacement of the face of the casting would be half the amount of shrinkage if there were no lateral displacement of the core face. In the case of ferrous castings, this free lateral displacement of the casting face with respect to time would be represented by curve *a* in Fig. 6, the ordinates of which are half the ordinates of the curve for the shrinkage of cast iron, but, even here, the original displacement of the face of the plastic casting takes place under the effect of the core expanding in the opposite way, as in curve *b*. In this case, the plastic deformation of the casting is much greater than if there were zero lateral displacement. In addition, the casting appears to be elastically deformed by the core for a time, since the instant the core ceases to expand, and during the period when no further change occurs in dimensions, the casting is elastic and should decrease in size. The elastic deformation of the casting, however, is removed in the process of further cooling, since the core contracts more quickly than the faces of the casting are displaced. In the end, when there is no further elastic deformation, a gap starts to form between the casting and the core, but its size is insignificant. In order to illustrate the process whereby elastic deformation is removed and the gap formed, Fig. 6 shows not only curves *a* and *b*, but also curve a_1, which indicates how the change in the dimensions (i.e., the lateral displacement) of the casting would take place after being plastically deformed by the core if the core were to be removed instantly. It can be seen from this example that a gap is formed between the casting and the core after cooling in the case of a 50% displacement of the casting face, but that the size of the gap is so small that it can be regarded as the limiting case (i.e., the gap is practically zero). The size of the casting, as defined by the core, is also greater than it was at the start, even in this case (roughly 0·2% in the experiment concerned).

No experiments were made with castings having thinner walls, but it can be assumed that changes would not take place so quickly in the dimensions of the core if it were heated less by a thin-walled casting. Consequently, there may be no removal of elastic deformation or process of gap formation if the deformation of the casting is perceptibly reduced, compared with that illustrated in Fig. 6.

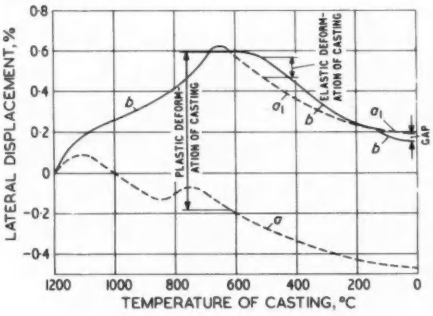


Fig. 6.

If there were 100% lateral displacement, the casting faces would be displaced in complete conformity with curve *a* in Fig. 7 for the shrinkage of cast iron under free shrinkage conditions, whereas, in actual fact, the lateral displacement of the casting face proceeds according to curve *b* for the variation in the dimensions of the core. If the core were removed at the instant that the casting changed into the plastic state, the change in its dimensions would be in accordance with curve a_1. In point of fact, however, the core, being in the elastically compressed state, deforms the casting right up to the end of the cooling period, since the rate at which it contracts is the same

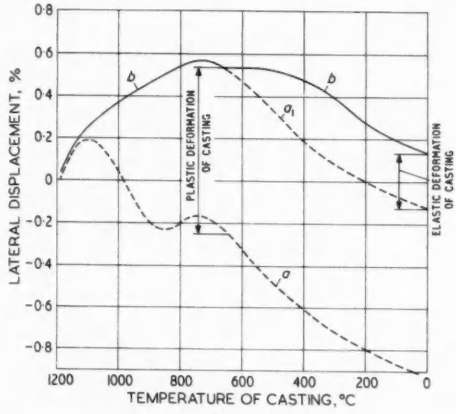


Fig. 7.

in this case as the rate at which the faces of the casting are laterally displaced. All in all, the casting is "heat-seated" on the core, and the amount of elastic deformation at the end of cooling is roughly 0·1 to 0·2%. This figure has been checked and confirmed by the gradual wear of the cores.

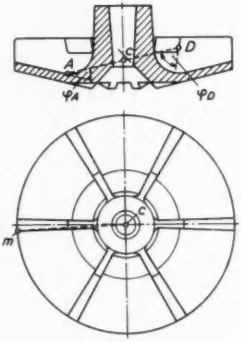


Fig. 8.

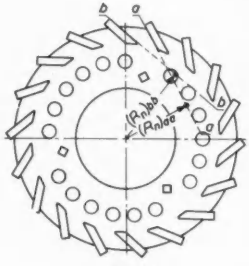


Fig. 9.

Not enough data have as yet been gathered to solve practical problems theoretically. There is not enough information about the permissible degree of plastic deformation of the casting metal and the permissible amount of elastic deformation, especially at high temperatures, and a complete study has still to be made of changes in the dimensions of metallic cores and moulds with different thicknesses, materials, etc. Nevertheless, the data obtained make it possible to design moulds and cores with respect to mechanical shrinkage restraint and to determine whether it is advisable or permissible to cool the casting to room temperature along with the metal mould. Given the permissible lateral displacement of the casting faces (e.g., if 50% lateral displacement is tolerable), it is possible to ascertain theoretically whether castings can be produced in metallic moulds.

In the present research, it was required to ascertain whether it was expedient to produce metallic moulds for casting impellers and diffusers. The impeller was a solid hub connected to a conical disc, with six blades arranged on the disc and extending to the periphery, as shown in Fig. 8. The impeller was required to be made with chilled blades and a chilled disc, so that it was necessary to use metallic cores and moulds. The points of projection of the geometric centre of the casting were first defined. The interaction of the side faces of the blade of the casting with the metallic mould was defined by studying the casting in plan view. By joining the extreme points of the projection of the lateral faces of the blades to the projection of the centre of the casting (Fig. 8), it was found that these lines passed inside the casting without intersecting the mould. This meant that the lateral faces of the impeller blades were no obstacle to the use of metallic moulds of any type, despite their thickening towards the periphery.

When considering the type of casting in the vertical projection, it was first necessary to check the internal face of the conical disc with respect to the nearest point *A* to the projection of the geometric centre *c*. At this point angle φ_A is roughly 25°, and lateral displacement of the face at this point will therefore be less than 50%. As previously established, there is no need to check lateral displacement at any other points on this face, since it is relatively smaller there than at point *A*. Thus, any type of metallic mould can be used on this face. The internal cone of the hub casting has surfaces almost facing the geometric centre (its projection); this means that the lateral displacement of these surfaces is practically zero and does not impede mechanical restraint of shrinkage.

Only faces *D* of the recesses in the blades of the casting form an alge φ_D of almost 90° i,.e., they have a lateral displacement of almost 100%. Thus, use can be made of the mould to obtain the complete outline of the impeller casting, except for the recesses in the blades, which must be made by sand cores.

The diffuser casting was a flat ring with eighteen vanes on one side, as shown in Fig. 9, and it was required to chill the vanes and adjacent surfaces of the ring. For this purpose, it was necessary to determine whether metallic cores could be set up between the vanes, making it essential to analyse the lateral displacement of the faces *aa* and *bb*. It was not the lateral displacement itself that was of interest in this case, but the relationship between the displacement of the two faces of the casting at an angle to each other. Lateral displacement amounted to $\alpha R_n \triangle t$, the values of α and $\triangle t$ being identical for the two faces of the casting at any given moment of time. Consequently, the difference between the displacement of the faces was determined by the geometric difference between $(R_n)_{aa}$ and $(R_n)_{bb}$, and, as indicated in Fig. 9, $(R_n)_{bb}$ is longer than $(R_n)_{aa}$. If a metallic core were made in such a way that it only filled the space between two vanes, the direction in which *aa* and *bb* are displaced would be practically the same. Consequently, the face *aa* of this core is freely displaced on the side of face *bb* without mechanical restraint of shrinkage taking place. If, however, the core is made in such a way that it fills two or three spaces in between vanes, the directions in which the extreme faces formed by the core are displaced will be considerably different, and mechanical restraint of shrinkage will therefore arise. The amount of restraint can be determined by the geometric subtraction of the vectors, equal in magnitude to $(R_n)_{aa}$ and $(R_n)_{bb}$, and coincident in direction with the perpendiculars to the extreme faces of the core.

REFERENCES

(1) A. G. Spasskyi: "Fundamentals of Foundry Production". Metallurgizdat, Russia, 1950.

(2) A. E. Krivoshiev: *Theory and Practice of Metallurgy*, No. 7-8, 1938.

Properties and Applications of Glass-Ceramics

By S. D. STOOKEY

From *Mechanical Engineering*, U.S.A.,
Vol 82, No. 10, October 1960,
pp. 65-68, 5 illustrations.

IN the three years since the discovery by the Corning Glass Works of a family of fine-grained crystalline materials, called glass-ceramics and trade-marked "Pyroceram", these materials are showing promise of finding increasing engineering and structural applications as new compositions are developed and further improvements in their properties continue. Thus, glass-ceramics, which are made from glass by a new process of controlled crystallization, have unique advantages over most ceramics and glass, and combine several factors which give them special value as engineering materials, including an almost ideal microstructure (i.e., fine-grained, uniform, and free from voids and flaws) and the capability of being "tailor-made" to possess various useful combinations of properties by variations in composition and processing.

In the manufacture of glass-ceramics, the batch ingredients, including the nucleating agent, are mixed and melted to a homogeneous molten glass, which, depending on the composition, may be nearly as fluid as molten metal or extremely viscous. The glass is held extremely uniform in composition, by stirring and other methods, in the same way as optical glass. The molten glass is formed by conventional glass-forming methods, such as pressing or blowing into moulds; drawing as tube, rod, or pipe; rolling or drawing into flat sheet; or centrifugal casting. The more fluid glasses may be cast into intricate shapes by methods similar to those used in metal casting, and the sizes and shapes that can be produced are virtually unlimited. After casting, the glassware is cooled. At this point, it is transparent and can readily be inspected for flaws or bubbles. Some compositions can be reheated and reworked into new shapes while still in the glassy state.

Although it is possible to form glass-ceramic articles reproducibly to reasonably close tolerances without further finishing, some high-precision shapes require finishing, but these materials can be ground and polished to very accurate dimensions by the methods used for glasses, ceramics, and hard metals.

The essential features of the thermal treatment of a glass-ceramic can be summarized as follows:—After the glass has been melted to a clear homogeneous liquid and formed to shape, it is cooled to the nucleation temperature (or cooled to room temperature and later reheated to the nucleation temperature). Holding at this temperature causes precipitation of an enormous number of uniformly dispersed subcolloidal crystal nuclei having a composition different from the major crystal phases. Subsequent heating to the growth temperature initiates growth of crystals of the major phase or phases on these nuclei. Holding at this temperature converts the glass article, substantially unchanged in size or shape, to the fine-grained crystalline Pyroceram, the crystals in which are normally smaller than 0·0001 in. in diameter and are randomly oriented.

Essentially, then, the stages of conversion of an amorphous glass to a typical glass-ceramic by heat treatment involve the formation of submicroscopic nuclei, followed by their growth and coalescence into larger crystals, culminating in the production of the matured glass-ceramic. Thus, the original glass, after nucleation at 720°C, shows a high concentration of particles, i.e., nuclei, with diameters of approximately 30 Å. After heating for 15 min at 1050°C, a reduction in the number of particles and an increase in their size take place. Finally, after the matured glass-ceramic has been crystallized by further heat treatment for 2 hr, the crystals are about 0·5 to 1·0 micron in diameter. The crystal size, even in the matured ceramic, is smaller and more uniform than that of conventional ceramics and of metals and is free from voids and from any preferred orientation. The major crystal phase in this material is a lithium aluminium silicate ($Li_2Al_2Si_6O_{16}$). Fig. 1 is an electron replica micrograph of the fractured surface of a typical matured glass-ceramic.

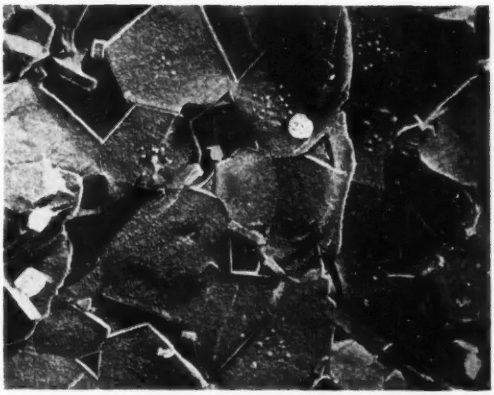


Fig. 1. Electron replica micrograph of the fractured surface of a matured glass-ceramic. (× 18,400)

With regard to the theory of the controlled crystallization process used, it may be said that, when a molten metal or a molten salt is cooled below its liquidus temperature, it crystallizes almost instantly, the crystallization being nucleated at cold surfaces and at the surfaces of foreign particles in the melt. In the case of the controlled crystallization of a glass-ceramic, crystallization of an undercooled melt takes place in two successive stages, i.e., nucleation and crystal growth. When the glass is cooled from above the liquidus of its major crystal phase, it passes through a temperature range in which crystals would be able to grow if nucleation had occurred previously. The crystal growth-rate curve reaches a maximum, and then decreases to zero with further cooling because of the enormous increase in viscosity. When the glass contains no nuclei, cooling through the "growth" range does not result in crystallization.

With still further cooling, a low-temperature range is reached in which nucleation and crystal growth of a minor phase—the "nucleating agent"—can occur. This takes place at a temperature below the crystal-growth range of the major phase, so that formation of the foreign particles occurs prior to, and independently of, crystallization of the major phase.

If the glass is then cooled and/or reheated to the nucleation range, held for an appropriate length of time, and then reheated to the crystal-growth range of temperature, each nucleus formed in the nucleating temperature

range becomes the centre of growth for a crystal of the major phase. By controlling the heating cycle, it is therefore possible to control both the number of crystals and their size.

Properties of Glass-Ceramics

Glass-ceramics are non-porous and generally have an opaque white appearance in the finished state, although some compositions may also be transparent. They are resistant to high temperatures in terms both of strength and oxidation, and are like glasses in their ability to resist chemical attack, with measured durabilities in weight loss ranging in values comparable with those of the durable chemical glasses. They are lighter and harder than most metals. In thermal conductivity they are classed as heat insulators, their coefficients of thermal expansion ranging from negative values, through zero, to positive values. Extreme heat-shock resistance and dimensional stability with temperature may be obtained by choice of composition to provide coefficients of expansion near zero.

In electrical properties, most glass-ceramics are classed as electrical insulators, having dielectric constants from 5 to 10 and power factors at high frequencies ranging down to extremely low values. In mechanical properties, these materials generally have a higher Young's modulus than glasses, ranging from 12·5 to some 20×10^6 psi, with strengths higher than those of glasses and most ceramics. Glass-ceramics are not ductile or malleable, but are classed as brittle materials.

TABLE 1: PROPERTIES OF GLASS-CERAMICS

	Pyroceram 9606	Pyroceram 9608
Specific gravity at 77°F	2·60	2·50
Water absorption [%]	0·00	0·00
Porosity	gastight	gastight
Softening temperature [°F]	2282	2282
Specific heat at 77°F	0·185	0·190
Mean specific heat (77 to 572°F)	0·230	0·235
Thermal conductivity at 77°F mean temperature [BTU/hr ft °F]	2·10	1·13
Linear coefficient of thermal expansion (77 to 572°F)	$31{\cdot}6 \times 10^{-7}$	†3·9 to 11·1 $\times 10^{-7}$
Modulus of elasticity [psi]	$17{\cdot}3 \times 10^6$	$12{\cdot}5 \times 10^6$
Poisson's ratio	0·245	0·250
Modulus of rupture (abraded) [psi]	20×10^3	16 to 23 $\times 10^3$
Knoop hardness [100-gm]	698	703

† Depending on heat treatment.

Various compositions can be tailor-made to meet desired properties, with the final control depending on special heat-treatment. Two compositions, i.e., Pyroceram 9606 and 9608, the properties of which are listed in Table I, are now available commercially. Pyroceram 9606 is suitable for high-temperature, high-frequency applications in the field of electronics, the maximum usable temperature under load being 1560°F for 1000 hr. It is already being used successfully as a missile radome, and its hardness and ability to withstand high temperatures have made it suitable for consideration as an abrasive binder and for bearing parts. Special glass-melting techniques are used on this material to ensure uniform composition, constant density, freedom from bubbles and striations, and uniform electrical properties. It is most easily formed by gravity and centrifugal casting and, with certain limitations, it can be pressed and rolled.

Pyroceram 9608 is especially useful for its low coefficient of thermal expansion, which gives it immunity to breakage by thermal shock and imparts unique dimensional stability.

Applications of Glass-Ceramics

Under conditions of high-temperature, dry (unlubricated) operation and in the presence of corrosive media, even the best metal bearings may perform poorly, and the metals which perform best are expensive, difficult to fabricate, and heavy. In this connection, a thorough evaluation of glass-ceramic bearings for such service is being made by a number of laboratories and bearing manufacturers. Surprisingly enough, it has been found that glass-ceramic bearings can be finished almost as easily as steel bearings and with the same equipment.

The sliding and rolling characteristics of Pyroceram 9606 and 9608 are being tested against themselves and against various metals, operating dry at up to 1800°F and also in various corrosive liquids, as well as with lubricants. Although it is too early to give a conclusive report, the results are promising.

Bearing systems of various types, combining Pyroceram with such materials as Hastelloy C, Stellite 3, and titanium carbide, have been successfully operated dry at 1000° to 1800°F in some cases, under conditions that caused the best all-metal systems to seize or fail. In addition, the results of thrust-bearing load tests made to determine the compression load show that the material fails in a brittle fracture at about the same compressive stress that causes steel to flow, i.e., at about 380,000 psi.

Similarly, combinations of Pyroceram with itself and with accepted corrosion-resistant metals such as Hastelloy B or Type 304 stainless steel in various liquids, including concentrated solutions of nitric acid, sodium hydroxide, citric acid, and ferric chloride, as well as in 30% hydrogen peroxide and in molten lead at 700°F, show lower coefficients of friction and lower wear, or lower surface damage than Hastelloy B running against itself. It should be noted that the friction and wear of Pyroceram, when sliding or rolling against itself without lubrication, are rather high, and that it is more satisfactory to use it in combination with certain metals.

Another field of application of these materials is in high-temperature heat exchangers, because of their thermal-shock resistance and dimensional stability. In fact, one type has already been developed for use in high-temperature turbines.

Because of their dimensional stability, a potential application of glass-ceramics appears to be in precision instruments and machine-tool components. In this connection, as the requirements for instruments and machines become more stringent, the gauges and machine tools needed to make them must become still more precise in dimensions, and, if these are made of relatively high-expansion metals such as steel, the dimensions vary with temperature. The expansion coefficient of Pyroceram 9608 between 0 and 100°C is so nearly zero, when the material has been specially processed, that no measureable change in length occurs in this temperature range. For this reason, it should be a useful material for precision gauges, for the beds of special machine tools, etc.

Insofar as future development is concerned, an active programme is under way, with the object of developing glass-ceramics capable of maintaining their strength up to 2500°F and even higher, of increasing their strength, hardness, and wear resistance, and of producing tailor-made compositions with expansions to match various metals, or other useful combinations of properties.

X-Ray Inspection of Hot Steel Billets during Rolling

By W. J. OOSTERKAMP, J. PROPER, and M. C. TEVES

From *Philips Technical Review*, Netherlands, Vol. 21, No. 10, 1959–60, pp. 281–285, 5 illustrations.

A PROBLEM encountered in the reduction of hot billets to bars by rolling is that blowholes and slag inclusions, formed during solidification of the steel, materially weaken the finished product. Defects of this kind are particularly prevalent in the front end of the billet, i.e., the crop, and it is therefore the practice to cut off a considerable length of the billet and discard it as scrap. Inspection of the cut face then reveals whether too much or too little has been discarded. However, it is very difficult to observe such defects clearly on the red-hot metal. Consequently, it is quite possible that, in fact, too little has been removed, resulting in poor-quality steel being passed for further processing, or that, to be on the safe side, too much has been cut off, resulting in a waste of good material.

It is thus evident that X-ray investigation of the hot billets in the rolling mill would result in a considerable saving of material and also make for a more reliable product. Furthermore, it would show whether defects were present in parts of the billet other than the crop, and would provide a practical and simple means of investigating the effect of various production factors on the formation of cavities and other casting defects.

Conventional industrial X-ray equipment, with a radiation source of up to 300 keV, is quite inadequate for detecting holes or inclusions measuring only a few millimetres in a steel billet at least 8 in. in thickness, which, moreover, is moving at a rate of 1 to 2 fps.

Plans were therefore developed in a German steelworks to tackle this problem with the aid of a betatron as the radiation source, an X-ray image intensifier, and a closed-circuit television system for final display. The betatron radiation source generates X-ray energies up to 31 MeV, and this extremely hard radiation can be used for the fluoroscopy of relatively very thick materials. Also, X-ray energy in the region of 30 MeV yields the greatest penetrating power ; at higher energies, the absorption in steel progressively increases as a result of pair production. Nevertheless, the half-value layer of steel for 31-MeV radiation is only 34 mm, which is still much less than the object thickness. After traversing 200 mm of steel, the rays are reduced in intensity to about 1% of the initial value. Observation at this low residual intensity is made possible by the X-ray image intensifier described later.

The television system for remote display of the image formed on the viewing screen of the image-intensifier tube makes use of an image-orthicon camera tube, a full-size image of the viewing screen being formed in the usual way on the photo-cathode of the image orthicon by a conventional optical system. The use of television offers several advantages, i.e., (1) it is the best answer to the problem of safely positioning the observer ; (2) its extremely sensitive image orthicon permits a luminance gain to be obtained which supplements that of the image intensifier ; and (3) it is a simple matter in a television circuit to provide for contrast intensification. All these factors make it possible to achieve better detail perceptibility than if the viewing screen were observed by means of mirrors and a telescope.

A schematic layout of the installation is shown in Fig. 1, from which it can be seen that the betatron (1) generates a beam of 31-MeV X-rays (2), which is passed through a copper equalizing absorber (3) to obtain uniform intensity distribution. The steel billet (4) moves along a line of rollers (5). Also shown are the X-ray image intensifier tube (6) with a lead layer (7) over an aluminium window, the optical system (8), the television-camera tube (9), the television video circuits (10), and the display tube (11). The aluminium plate (12) shields the betatron (1) from the heat generated by the hot steel (4), the water-cooled heat-radiation shield (13) protects the image-intensifier tube (6), and the lead shield (14) prevents scattered X-rays from penetrating the image intensifier.

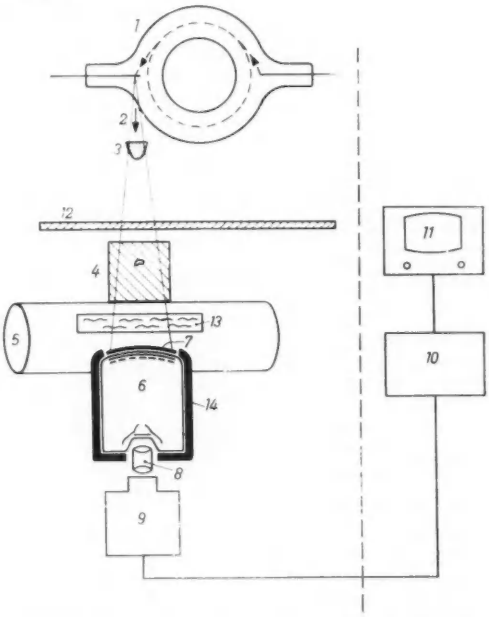


Fig. 1. Schematic layout of X-ray installation for the inspection of hot billets.

The image intensifier, shown in Fig. 2, operates on the principle that X-rays falling on a fluorescent screen Fl_1 excite an image, the photons of which release electrons from a photo-cathode K in contact with this fluorescent screen. These electrons are accelerated by a high potential and focused on a second fluorescent screen, the viewing screen Fl_2. The image intensifier has a tube wall made entirely of aluminium and gives an electron-optical reduction of more than 10, the overall luminance gain being about 1200. The field of the image intensifier, i.e., the diameter of the X-ray fluorescent screen, is 9 in. A layer of lead, 2 mm thick, is fitted over the aluminium window of the intensifier, because only a very small fraction of the 31-MeV radiation is directly absorbed by

the X-ray screen and used for producing fluorescent light. In the lead, the 31-MeV X-rays release electrons which have an energy of about 10-MeV and travel in a direction not very different from that of the beam of X-rays. These electrons pass through the aluminium window without appreciable scattering, as the window is only 1 mm in thickness, and excite about 4000 photons of fluorescent light per electron in the fluorescent screen Fl_1. Image intensification then takes place, each 10-MeV electron from the lead finally giving rise to 400,000 light photons from the viewing screen Fl_2.

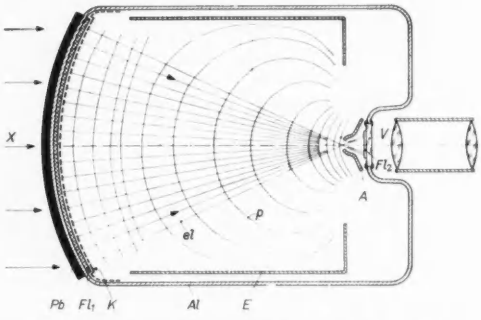


Fig. 2. Cross-section through X-ray image intensifier. *A* = anode; *V* = glass viewing window; *E* = focusing electrode; *el* = electron paths; *p* = equipotential surfaces; *K* = photo-cathode; Fl_1 = X-ray screen; Fl_2 = viewing screen.

The extremely high gain obtained in the X-ray image intensifier (and in the television circuit) does not alter the fact that the information, on arrival in the image intensifier, is carried by a relatively low number of X-ray quanta. A high noise level in the picture is therefore inevitable. This effect is to some extent reduced by the afterglow of the television picture tube, in which each image element is integrated over a certain time. However, afterglow persistence must not be unduly long, in view of the fact that the steel billet is a moving object.

In spite of the remaining noise, the installation has given surprisingly good results. Penetrameter measurements, i.e., determination of the thinnest wires still perceptible, indicate that 4-mm dia. steel wires on the billet can still be observed. A statistical analysis, based on a comparison of casting defects found during the screening of several thousand hot steel billets with defects found during subsequent inspection of cold-sawn sections, leads to the conclusion that X-ray screening discloses 50% of all 3-mm blowholes and 90% of all 7-mm blowholes.

New Developments in Ni/Ni-Cr Thermocouples

By B. E. EDWIN

From *Elektrowärme*, Germany,
Vol. 18, No. 7, July 1960,
pp. 222-225, 4 illustrations.

ALTHOUGH alloys of precious metals are sometimes used for the purpose, thermocouples for the temperature range between 500 and 1100°C usually employ elements consisting of a nickel and a nickel-chromium alloy. For many years, at least until 1950, the composition of these thermocouple materials remained substantially unchanged, the negative conductor consisting essentially of nickel with from 1·5 to 2·5% aluminium, 1·0 to 1·2% silicon, and 1·8 to 3·0% manganese, and the positive conductor 9·0 to 9·5% chromium and 0·1 to 0·5% silicon, in both cases with the addition of smaller accurately controlled quantities of other elements. In addition, some manufacturers have also produced positive conductors containing a relatively high percentage of manganese.

In the course of time, these materials have been perfected in respect of their temperature/e.m.f. characteristics, and are being widely used in various countries. However, they suffer from the disadvantage that the oxidation resistance of the negative element is low, compared with that of the positive element, and that the useful life of the thermocouple is determined, for the most part, by the negative element. In this connection, efforts to find a substitute for the conventional nickel-base materials used in the negative element have been rendered more difficult by the fact that the Standards Institutions of many countries have adopted standard temperature/e.m.f. characteristics, which have, in turn, formed the basis for the technical applications of thermocouples, so that any new material is required to produce a similar characteristic.

A recently developed alloy, designated "Thermo-Kanthal", meets these requirements for negative conductors and is based on nickel with approximately 2 to 3% silicon, plus small quantities of certain additives to improve oxidation resistance and to control e.m.f. characteristics. Fig. 1 illustrates the effect of heating in air at 1100°C for 1500 hr on a Thermo-Kanthal wire of 3·25 mm diameter, and a similar wire of a conventional negative-conductor material containing nickel with aluminium, silicon, and manganese. It will be seen that the conventional wire has been oxidized almost to the core, while the Thermo-Kanthal wire has been affected only to a very minor degree.

Fig. 1. Effect on (left) a Thermo-Kanthal wire of 3·25 mm diameter, and (right) a similar wire of a conventional negative-conductor material, after heating in air at 1100 C for 1500 hr.

A comparison of some of the more important properties of Thermo-Kanthal, compared with those of a conventional negative and positive material, is given in Table I, from which it can be seen that the only major difference is in the value for specific electrical resistance at 20°C, which is lower in the case of Thermo-Kanthal, and also in the resistance temperature coefficient, which is higher at low temperatures. Consequently, starting from equal values of resistance at room temperature, the resistance of a Thermo-Kanthal wire will remain below that of a conventional wire throughout the temperature range above this point.

With regard to calibration tolerances, it should be noted that the thermal e.m.f. of Ni/Ni-Cr couples

TABLE I: PROPERTIES OF THERMO-KANTHAL AND CONVENTIONAL CONDUCTORS

	Thermo-Kanthal	Negative Alloy	Positive Alloy
Melting point [°C]	1410	1400	1430
Specific resistance at 20°C	0·22	0·29	0·69
Resistance temperature coefficient per °C between 20 and 100°C	$30{\cdot}0 \times 10^{-4}$	$18{\cdot}8 \times 10^{-4}$	$3{\cdot}2 \times 10^{-4}$
Thermal conductivity at 20°C [cal/cm sec °C	0·07	0·07	0·05
Tensile strength (annealed) [kg/mm²]	51	59	65
Magnetic	Yes	Yes	No

operating at high temperatures alters in the course of time, as indicated in Fig. 2, which shows temperature deviations, compared with a platinum thermocouple, as a function of time, for a thermocouple with a conventional negative conductor and for a similar thermocouple with a Thermo-Kanthal negative conductor, in both cases using wires of 3·25 mm diameter and an applied temperature in air of 1100°C. It will be seen from Fig. 2 that Thermo-Kanthal is also superior to conventional materials in respect of stability.

The different behaviour of these materials can be explained by the fact that their individual components have different rates of oxidation, thereby changing the original composition of the alloy. In the case of conventional nickel-base thermocouples, the aluminium, silicon, and manganese oxidize more rapidly and, since changes of content of these elements influence the thermal e.m.f. to a relatively high degree, the changes indicated by the curve in Fig. 2 can easily be understood. In the Thermo-Kanthal alloy, the component with the highest rate of oxidation is silicon, and it is for this reason that the silicon content of Thermo-Kanthal has been made so high that any diminution can hardly affect the thermal e.m.f.

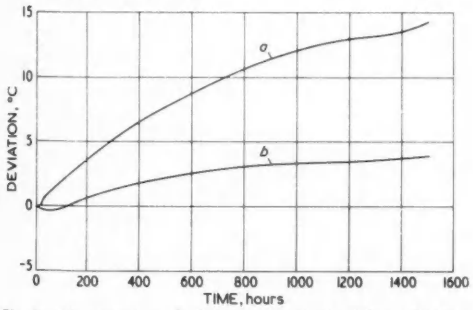


Fig. 2. Temperature deviation, compared with a platinum thermocouple, as a function of time, (a) for a thermocouple with a conventional negative conductor and (b) for a similar thermocouple with a Thermo-Kanthal negative conductor.

When considering the question of stability of thermocouples, attention should be given to conditions other than those appertaining to their operation in uncontaminated air. It is well known that occasionally the characteristic of a thermocouple may suddenly change, and that thermocouples operating in sulphur-containing atmospheres rapidly perish. It is therefore desirable to avoid contact with such atmospheres. However, in certain cases, effects similar to attacks by sulphur may be diagnosed when, in fact, the atmosphere in the furnaces itself has been free from this element. In some of these instances, it has been possible to establish as the cause of damage traces of sulphur-containing oil in the protecting tube. It is therefore essential to make sure that such tubes are absolutely clean, and it has been found advantageous to bring them to red heat before they are used. More recently, it has occasionally been observed that, despite the use of clean protecting tubes, the values of thermal e.m.f. have shown abnormal variations under certain conditions. In these cases, it has been established that selective oxidation of the chromium took place. Such oxidation can occur if the partial oxygen pressure falls below a certain low value, and it must therefore be presumed that the oxidation of metallic protecting tubes, as well as the burning of impurities in the tube, is responsible for using up the oxygen. Consequently, the diameter of the protecting tube should be selected sufficiently large and care should be taken to ensure an adequate supply of fresh oxygen. As a result, the length of the protecting tube must be limited in relation to the diameter; furthermore, the tube must not be made gas-tight.

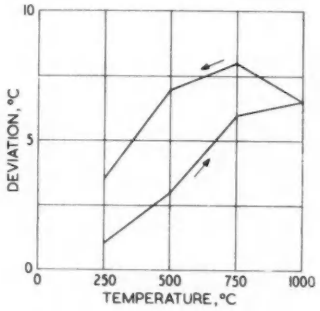


Fig. 3. Calibration curves for a thermocouple under conditions of rising and falling temperature.

Relatively recently, it has been found that the calibration curve of a thermocouple, taken with the temperature rising, is not identical to the curve recorded with the temperature falling. This hysteresis of the calibration curve may cause thermocouples which have been calibrated on the basis of increasing temperature to exceed the prescribed tolerances at certain temperatures after their initial cooling down in the furnace. In respect of this hysteresis, the positive conductor is more sensitive than the negative conductor. Fig. 3 shows the order of magnitude of this phenomenon, for which no real explanation has so far been found.

A further property which is in close connection with deviations of the thermal e.m.f. is the homogeneity of the wire. If the material is not entirely homogeneous, an additional thermal e.m.f. may be set up in those sections on which there is a temperature gradient, and this may affect the accuracy of the couple. The homogeneity of a wire may be tested by threading it through a furnace in which there is a high temperature gradient and measuring whether an e.m.f. is set up between its ends.

Since, in operation, a thermocouple is always subject to a temperature gradient, oxidation of the wires will not be uniform over their length. Furthermore, even in sections where the temperature distribution shows no gradient, there may be differences in the separation of carbides and nitrides. These changes eventually produce a degree of non-homogeneity and hence changes in characteristics; these changes must be taken into account when thermocouples are recalibrated, and recalibration should never be effected outside their normal operating positions and temperature gradients.

Improved Design of Anodo-Mechanical Sawing Machine

By V. I. KURCHENKO
From *Stanki i Instrument*, Russia,
Vol. 31, No. 8, August 1960,
pp. 35-37, 2 illustrations.

BASICALLY, the anodo-mechanical sawing process employs a rotating steel disc, which constitutes one electrode, the other electrode being the workpiece, and the circuit is closed via an electrolyte, usually water-glass, supplied continuously to the cutting zone. During cutting, the electrolyte dissolves the outer layer of the workpiece and creates a low-strength film on its surface, permitting the rotating disc to penetrate into the metal and to effect the cutting action. Essentially, two distinct processes take place simultaneously during cutting, i.e., electro-chemical dissolution and electro-erosion of the metal. At high current rates the effects of electro-erosion, and at low current conditions the effects of electro-chemical action are more manifest.

The widespread application of this process is due to the fact that, by means of anodo-mechanical sawing, smoother cuts, a reduced volume of metal removal, and in certain cases higher cutting speeds can be achieved than with conventional mechanical sawing. Also, this process makes it possible to cut high-alloy steel and certain light-alloy components which cannot be cut by flame-cutting and the mechanical sawing of which is often inefficient. However, despite these inherent advantages, the first designs of anodo-mechanical sawing machines had a number of shortcomings, frequently causing wedging of the cutting disc in the workpiece, distorted cuts, and flash at the end of cuts. In order to overcome these difficulties, an anodo-mechanical sawing machine of improved design has been developed in Russia and is claimed to eliminate the risk of wedging, to improve the surface of the cuts, and to increase the productivity of cutting by a factor of 2·5 to 4.

In this improved machine (Fig. 1), a thin steel disc (1), situated in an enclosed chamber (2), is rotated by a belt drive through a pulley (5), electric current being supplied to the disc via brushes (4) and to the workpiece via brushes (10). The chamber (2) is rubber-sealed to eliminate splash of the electrolyte and is provided with a fume-extractor (3) and a sealed glass inspection window. The electrolyte is supplied to the cutting zone from a container (7) by a pump (6) through nozzles (13).

One of the novel features of this design is the use of special guides for the cutting disc. The guides comprise two pairs of ceramic plates (15), fixed in metallic holders (14) and located at each side of the workpiece. The use of these guides permits rapid adjustment of the cutting discs with a minimum clearance between the discs and the ceramic plates. In addition, with the new arrangement, the width of the steel disc can be substantially reduced, the perpendicularity of the cutting plane to the axis of the workpiece ensured, and the danger of short-circuits and of magnetic pull on the disc eliminated.

Further new features of the machine include pneumatic clamping of the workpiece by means of a pneumatic cylinder (9) and a pneumatic chuck (12) and rotation of the workpiece by a motor (8) through a reduction-gear unit (11). Owing to the rotation of the component, the time of contact between the cutting disc and component is reduced, the points of contact continuously changing their relative positions, so that the saw cut is continuously filled with electrolyte, the danger of dry friction is reduced, and the removal of eroded particles from the cutting zone is enhanced. Also, the constant change in the relative positions of the points of contact, coupled with the improved circulation of the electrolyte, causes a general lowering of the temperature and localization of the heat in the cutting zone, eliminating local metal flow on the cut faces.

The major advantages of the new machine are clearly indicated by comparing the cutting speeds and cutting-disc dimensions of a conventional and an improved anodo-mechanical sawing machine. For instance, with the conventional machine when cutting a steel bar of 200 mm diameter, a cutting disc of 800 mm diameter and 1·75 mm width is required and the cutting time is about 16 min, whereas with the machine of improved design the diameter of the disc can be reduced to 500 mm and the width of the disc to 0·8 mm, with a cutting time of only 7 min. Under these conditions, with the new machine, a saw-cut width of no more than 1 mm is obtained, with a corresponding reduction in the volume of metal removed.

Some of the advanced design features of the new machine can to a certain degree be used to achieve an improvement in the performance of conventional anodo-mechanical sawing machines. These machines can easily be equipped with guides of similar construction to that of

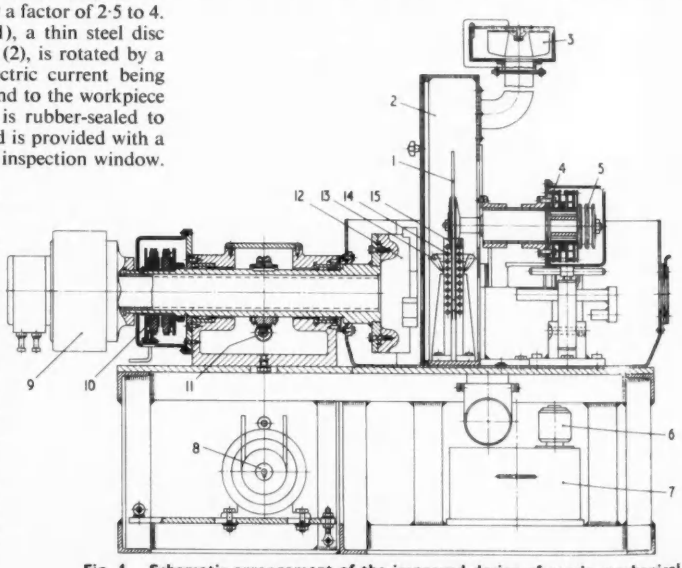


Fig. 1. Schematic arrangement of the improved design of anodo-mechanical sawing machine.

the new machine, and, in addition, the mechanical clamping of the workpiece can also be replaced by pneumatic clamping. Wedging of the cutting disc can be reduced by offsetting the axis of the disc by a distance which is equal to or longer than the diameter of the workpiece. In this case, the metal particles removed will leave the saw cut along a descending, instead of an ascending, path, reducing the risk of seizure of the disc and of metal flow on the cut face. It is also recommended that the workpiece should be turned through an angle of 30 to 45 deg. after the first half has been cut, in order to reduce the area of contact between the disc and workpiece, to retain a greater volume of electrolyte in the saw cut, and to eliminate completely the risk of wedging and metal flow during the second half of the cutting operation.

It must be noted that, during cutting, a hard layer is formed on the cut faces of the workpiece, rendering further machining troublesome. It is therefore advisable to normalize the cut workpiece prior to machining operations. If, however, there is no time for heat treatment, the workpiece should be rough-machined with a hard-alloy cutter first along its axis and then on its face. An exception is in the case of stainless-steel components, on the cut face of which no hard layer is formed, so that they can be machined immediately after sawing without any deleterious effects.

Investigation into the Development of Wrought Cobalt-Tungsten-Base Alloys

By E. F. Adkins, D. N. Williams, and R. I. Jaffee

From *Cobalt*, Belgium, No. 8, September 1960, pp. 16-29, 10 illustrations.

In 1933, Sykes*, one of the first investigators of the cobalt-tungsten system, showed that cobalt alloys containing up to 35% tungsten were subject to precipitation hardening and developed sintered alloys of cobalt containing from 20 to 35% tungsten for use as swaging dies for hot-working tungsten. The Co-35%W alloy developed a maximum Brinell hardness of 770 after solution-treating at 1400°C and ageing at 600°C, and is one of the hardest non-ferrous alloys known, comparable in this respect with the high-speed steels.

The incentive to further research provided by the above observations has been strengthened by the results of some preliminary work which showed that binary Co-W alloys could be hot-rolled at 1200 and 1300°C, although some difficulty would be encountered in the fabrication of alloys of high tungsten content. As a result, a programme of research, under the sponsorship of the Centre d'Information du Cobalt, Brussels, has been carried out in the U.S.A. by the Battelle Memorial Institute, and is concerned with the fabrication and heat-treatment techniques for binary alloys of cobalt containing up to 35% tungsten, and also on the effects of ternary additions on a selected cobalt-tungsten base.

In this investigation, cobalt in the form of rondelles (99·94% pure) and also in the form of electrolytically refined plaquettes (99·76% pure) was used in conjunction with $\frac{1}{8}$-in. diameter undoped tungsten rod (99·95% pure) as the melting stock in preparing the alloys. The rondelles, $\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. in length, were used in their original condition, while the $\frac{3}{32}$-in. electrolytic cobalt plaquettes were broken into pieces about $\frac{1}{2}$ in. square. The tungsten rod was crushed into small particles to speed up homogenization during melting.

Binary Alloys

All cobalt and cobalt binary-alloy buttons were consolidated by arc-melting under helium on a water-cooled copper hearth, using a tungsten electrode tip, presumed to be inert to the melting action. A minimum of six melts was given to each button to ensure complete homogenization of the composition. Two additional melts were made to shape the buttons into a form suitable for forging. All the binary alloys, which contained from 5 to 35% tungsten, had good melting characteristics, as each had sufficient surface tension to permit rocking of the molten charge in the furnace without its sticking to the hearth, so as to aid homogenization and to remove gases.

The hardness of the cobalt-tungsten binary alloys as a function of tungsten content, both as-cast and solution-treated, is shown in Fig. 1, from which it will be seen that the hardness of the as-cast alloy increases with increasing tungsten content up to a maximum of about 305 VHN with 15% tungsten. It is believed that this is related to the martensitic transformation occurring after quenching in the range of composition of from 0 to 20% tungsten.

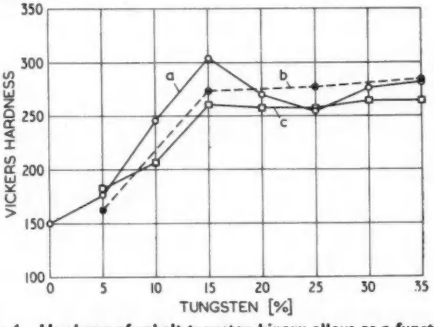


Fig. 1. Hardness of cobalt-tungsten binary alloys as a function of tungsten content, (*a*) as-cast, (*b*) solution-treated (air-cooled), and (*c*) solution-treated (water-quenched).

Preliminary tests showed that alloys containing 25 and 35% tungsten were susceptible to cracking during forging. Microscopic examination revealed that failure occurred along segregated lines of a second phase, presumably a tungsten-cobalt intermetallic compound or precipitated impurities. In order to minimize this

* W. P. Sykes: "The Cobalt-Tungsten System"; *Trans. Amer. Soc. Steel Treating*, Vol. 21, 1933, pp. 385-423.

effect, all buttons were thereafter homogenized prior to fabrication.

In the usual fabrication procedure, the buttons were held for 1 hr at the forging temperature in a hydrogen atmosphere, and then forged to a cross-section approximately ½-in. square, reheated, and water-quenched. Any surface cracks or laps were removed by grinding. The bars were then heated in hydrogen at 1350°C and rolled through nine different-sized openings into rods having square cross-sections with 0·265 to 0·271-in. diagonals. The rods were then swaged, at the same temperature, through six sets of dies to a final diameter of 0·255 in. Finally, they were reheated and water-quenched.

All the cobalt buttons were worked at 1000°C without difficulty. The cobalt-tungsten binary alloys were usually fabricated at 1350°C. Although one Co-35%W rod ruptured severely on the final swaging pass, the operation was performed successfully on subsequent Co-35%W rods. Alloys of Co with 5%W, 15%W, 25%W, and 35%W were swaged at 1150°C in an attempt to produce a smaller finished grain size; however, centre cracking occurred in all but the Co-15%W rod.

All the cobalt-tungsten alloys were solution-treated by heating for 1 hr at 1400° or 1350°C in hydrogen, and quenching in water. Although Sykes, in the investigation previously referred to, reported that a maximum solution temperature produced optimum strength, the lower temperature (1350°C) is believed to be more advantageous in that it minimizes grain growth. Photomicrographs of solution-treated specimens showed the presence of a small amount of unknown precipitate in each alloy. Duplicate cobalt-tungsten binary alloys, air-cooled after solution treatment, exhibited no significant difference in microstructure.

The solution-treated hardnesses followed the same general pattern as that for the as-cast materials, with the air-cooled specimens somewhat harder than the water-quenched specimens, as shown in Fig. 1. This difference in hardness levels may be attributed to a greater amount of precipitation during air cooling.

Solution-heat-treated samples of the Co-5%W, Co-15%W, Co-25%W, and Co-35%W alloys were aged for various times up to 256 hr at temperatures between 300 and 900°C. All samples were water-quenched before ageing, except those aged at 600°C, which were both water-quenched and air-cooled from 1350°C. Little or no age-hardening was apparent in the Co-5%W alloy when aged at between 300 and 600°C. Some increase in hardness was encountered in the Co-15%W alloy on ageing at 600°C, while considerable hardening was observed in the Co-25%W and Co-35%W alloys on ageing at between 600 and 800° C. Maximum hardnesses of 762 VHN and 870 VHN respectively were developed in the Co-25%W alloy after ageing for 256 hr at 600°C and in the Co-35%W alloy after ageing for 16 hr at 800°C. The shape of the ageing curves at 600°C for both these alloys showed that even higher hardnesses might be obtained by increasing the ageing time.

Short-Time Tensile Strength

Room-temperature tensile-strength tests were made on both forms of unalloyed cobalt under different solution-treated conditions of temperature, i.e., between 925° and 1400°C, but, because of the brittle nature of the fractures, it was difficult to make any conclusive statement regarding the effects of heat treatment and type of cobalt on the tensile properties, but, in general, those for rondelle were higher than for electrolytic cobalt.

In the case of the solution-treated cobalt-tungsten binary alloys, their tensile properties were considerably lower than expected. The brittle-type fracture that occurred in every case undoubtedly caused premature failure. The highest strength-ductility combinations resulted with the Co-30%W and Co-35%W alloys.

Binary alloys containing up to 35%W were tensile-tested after ageing for 256 hr at 600 to 900°C, the ageing treatments increasing the ultimate strength by a factor of 2 or 3%. However, the alloys proved to be extremely brittle, with failure occurring before the 0·2% offset yield strength in many cases. Fig. 2 shows the relationship between the 0·2% yield strength and the tungsten content for alloys in both the solution-treated and solution-treated and aged conditions, the ageing response being greatest at about 20% tungsten. The Co-30% W and Co-35% W alloys were also tested after ageing for 16 hr at 850°C. Considerable strength improvements were noted over the other aged specimens, but these alloys also fractured in a brittle manner.

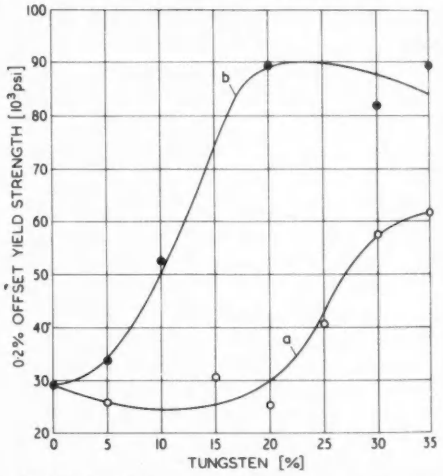


Fig. 2. Relationship between the yield strength and tungsten content of cobalt-tungsten binary alloys, (*a*) solution-treated, and (*b*) solution-treated and aged for 256 hr at 600° to 900°C.

The brittleness of cobalt and the cobalt-tungsten alloys is believed to be due to impurities. The relatively large grain size obtained as a result of the high fabrication temperature may also be a contributing factor. Small additions of cerium and yttrium were made in an attempt to impart ductility to the cobalt-tungsten alloys. Although metallographic examination of vacuum-melted Co-20%W ingots containing 0·1% Ce or 0·1% Y showed that these additions were effective in removing what appears to be oxide impurities in the grain boundaries of the base metal, no improvement in ductility was achieved. Larger additions were also tried (0·4% Ce and 0·5% Y), but cracking resulted during fabrication, owing to the formation of a foreign phase.

Stress-Rupture Strength

Elevated-temperature stress-rupture tests were made on Co-25%W and Co-30%W alloys in air at 816°C and 20,000 psi, the specimens used being of the same type as those used in the previous test. The Co-25%W alloy broke on loading, while the Co-30% W alloy had a life of 3·7 hr. Thus, these binary alloys exhibit relatively poor rupture properties.

Hot Hardness

Hot-hardness measurements were made on the Co-25%W and Co-35%W alloys after ageing for 64 hr at 700°C, and for 16 hr at 800°C respectively. As expected, the alloy with the higher tungsten content was harder at all temperatures, values ranging from 620 VHN at room temperature down to 40 VHN at 1093°C for the Co-25%W alloy and from 790 VHN down to 100 VHN for the Co-35%W alloy under the same temperature conditions.

Oxidation Behaviour

Oxidation specimens of cobalt and of cobalt alloys containing 5%, 10%, 15%, 20%, 25%, 30%, and 35% tungsten were heated for 16 hr at 800°, 1000°, and 1200°C in a furnace which allowed air to flow through a hole, ½ in. in diameter, in the door.

It was found that the specimens, which were sections of solution-treated rods, ¼ in. in diameter and ½ in. in length, were covered with a thin, grey, adherent scale when heated to 800° and 1000°C, while the specimens which had been oxidized at 1200°C exhibited a thicker adherent scale. The oxide, which was duplex, was black at the metal/oxide interface, and grey towards the surface.

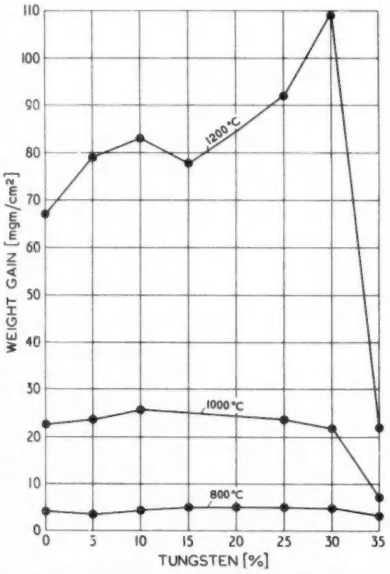


Fig. 3. Oxidation behaviour of cobalt-tungsten binary alloys heated for 16 hr at 800°C, 1000°C, and 1200°C.

Weight gain as a function of tungsten content is plotted in Fig. 3, from which it can be seen that, with the exception of the Co-35%W alloy, little if any improvement is derived from the additions of tungsten.

Cobalt-Tungsten-Base Ternary Alloys

Although a conclusive choice of a base composition could not be made because of the brittle behaviour of all the binary alloys, it was decided to use the Co-25%W alloy for studies on the effect of ternary additions, as it had relatively high strength after ageing for 256 hr at 900°C. Another reason for this choice was that it did not appear to have overaged during this treatment.

The ternary additions employed were chromium, molybdenum, columbium, tantalum, nickel, iron, and manganese (5% in each case); silicon, boron, aluminium, titanium, and zirconium (1% in each case); 0·50% platinum ; and 0·25% carbon. The ternary alloys were melted by the procedure already outlined for the binary alloys. An attempt was made to introduce nitrogen into the base composition by arc-melting under nitrogen, but a satisfactory button could not be obtained.

All the alloys were fabricated at 1350°C to ¼-in. diameter rod, with the exception of those containing the columbium, tantalum, boron, and zirconium additions, which cracked severely during forging. As metallographic examination revealed that failure was due to hot shortness, a second attempt was made to work these four alloys at lower temperatures. The Co-25%W alloys with additions of 5% Ta, 1% B, and 1% Zr were successfully fabricated to rod at 1000, 1100, and 1200°C respectively. The Co-25%W-5%Cb alloy cracked severely during forging at 1200°C.

The ageing behaviour of the ternary cobalt-tungsten-base alloys was determined by examination of their hardness and microstructure after quenching, to produce a predominantly alpha structure, and ageing at 700, 800, and 900°C. Three of the ternary additions (boron carbon, and zirconium) resulted in the formation of compounds. The Co-25%W-1%B alloy presented so many boride particles that its structure was obscured; its hardness was 463 VHN as-quenched, and ageing response was slight. The addition of 0·25%C to Co-25%W resulted in the presence of some carbides, but not in large amounts; the ageing response was rapid, but the maximum hardness reached was considerably less than that of Co-25% W, owing presumably to the lowering of the tungsten content of the matrix through the formation of carbides. In the Co-25%W-1% Zr alloy, the second phase present suggests grain-boundary melting during solution heat treatment; the presence of zirconium also appears to retard the eutectoid decomposition of alpha on ageing.

Additions of 5% Cr, 5% Mo, and 5% Ta to Co-25%W resulted in microstructural changes on ageing analogous with those in Co-30%W or -35% W. It appears that chromium, molybdenum, and tantalum substitute for tungsten on a roughly equivalent basis, if the compositions are expressed as an atomic percentage. Thus, examination of the data showed that the ageing response of Co-25%W-5% Mo, which contains 13·7 at.%W + Mo, is midway between those of Co-30%W and Co-35%W, which contain 12·1 and 14·7 at.%W respectively. The ageing response of Co-25%W-5%Ta, which contains 12·1 at.%W + Ta, is similar to that of Co-30%W (12·1 at.%W), and the ageing response of Co-25%W-5% Cr, which contains 16·4 at.%W + Cr, is more sluggish than that of Co-35% W(14·7 at.%W).

The addition of 5% Ni, 5% Mn, 1% Si, or 0·5% Pt does not greatly alter the mode of transformation, but the rate is changed. Compared with a Co-25%W base, the reaction rate is decreased most by 1% Si, and least by 5% Ni. None of these alloys becomes as hard as Co-25%W on ageing.

The alloy containing 5% Fe did not harden to the same extent as Co-25%W, while the alloy containing 10 Al differed little from Co-25%W in this respect. The addition of 1% Ti increased the maximum hardness attainable in Co-25% W on ageing at 800°C.

Of the various additions examined, the most useful from the standpoint of controlling the ageing response

are molybdenum, chromium, and tantalum, because of their ability to replace tungsten; silicon, because of its ability to reduce the rate of hardening; and titanium, because of its ability to increase hardness after ageing at higher temperatures.

Short-Time Tensile Properties

Room-temperature tensile properties were determined for the ternary alloys both in the solution-treated condition, and after ageing for 16 hr at 850°C. The same size of specimen and testing procedure were used as for the binary alloys.

All the ternary additions improved the room-temperature ductility of the Co-25%W solution-treated base composition. The elongation of the ternary alloys ranged from 4 to 11%, as compared with 2 to 4% for Co-25%W and Co-35%W. The yield and ultimate strengths of the solution-treated experimental alloys were generally comparable with those of the Co-30%W and -35%W alloys and higher than those of Co-25%W. The Co-25%W-1%B alloy was the strongest of the solution-treated alloys, with an ultimate strength of 181,000 psi.

The tests on the aged specimens showed that, in general, the ageing treatment increased the strength and lowered the ductility of the alloys, one exception being Co-25%W-1%B, whose ductility remained the same and whose strength decreased slightly. This alloy was the strongest of the aged alloys tested (116,600-psi and 177,000-psi yield and ultimate strengths respectively). The highest ductility was observed in Co-25%W-5% Fe (16% elongation). It should be emphasised that comparisons of the properties of aged alloys are not necessarily indicative of the relative potential of the ternary additions, since neither optimum ageing conditions nor optimum composition have been determined.

Stress-Rupture Properties

Stress-rupture life was measured on the Co-25%W alloy containing 0·25% C, 5% Cr, 5% Mo, 1% Ti, or 5% Ni under a stress of 20,000 psi at 816°C in air, and also on the same alloy containing 0·25% C or 5% Cr under the same stress, but at 982°C in air. The strongest ternary alloy at 816°C was the Co-25%W-0·25%C alloy, which ruptured after 244·8 hr, followed by the Co-25%W-5%Cr alloy, with a rupture time of 186·3 hr, the respective elongations being 4 and 5%. At 982°C, the Co-25%W-5%Cr alloy failed in 2·3 hr, and the Co-25%W-0·25%C alloy in 1·4 hr.

Hot Hardness

Hot-hardness measurements were made on the alloys with the highest room-temperature hardness after age-hardening. The hardest was the Co-25%W-5% Mo alloy (719 to 743 VHN after ageing for 64 hr at 700°C), its hardness being comparable with that of the binary Co-35%W alloy. Although the Co-25%W-5%Cr alloy proved softer at room temperature, its hardness curve remained relatively flat up to 900°C, where its hardness value was similar to that of Co-35%W and of Co-25%W-5%Mo. Both the Co-25%W-1%Al and Co-25%W-1%B alloys were softer than Co-35%W, but were comparable in this respect with Co-25%W.

Oxidation Behaviour

Cylindrical specimens, $\frac{1}{4}$ in. in diameter and $\frac{1}{2}$ in. in length, of the ternary alloys were exposed for 16 hr at 1000°C in still air, the weight gains noted ranging from 21·2 mgm/cm² for the Co-25%W-5%Mo alloy to 60·2 mgm/cm² for the Co-25%W-5%Ni alloy. The best ternary alloy, i.e., the Co-25%W-5%Mo alloy, was slightly more resistant than the Co-25%W binary alloy (23·8 mgm/cm²) or the Co-30%W alloy (22·1 mgm/cm²), but less so than the Co-35%W alloy (7·1 mgm/cm²).

Conclusions

The cobalt-tungsten binary alloys investigated, containing up to 35% tungsten, proved to be extremely brittle, both in the solution-treated and in the aged conditions. Consequently, very low tensile properties resulted. It is believed that impurities are the major cause of this condition, and that large grain sizes resulting from the high fabrication temperatures amplify the effect. The addition of ternary elements apparently acted upon the binary structures to tie up the dissolved impurities and in some cases to reduce the grain size. Ternary additions also resulted in the development of good stress-rupture properties.

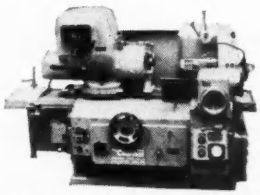
Examination of the experimental alloys developed so far indicates two areas of potential applications, i.e., as high-temperature structural materials and as tool materials. If the exceptional resistance to galling at elevated temperatures, characteristic of high-cobalt materials, is maintained in the cobalt-tungsten-base alloys, these may also prove useful in bearing applications.

The high-temperature properties of cobalt-tungsten alloys appear to be satisfactory, and it seems quite likely that improvements could be obtained by suitably modifying their composition or heat treatment. Such improvements would contribute to raise the service-temperature limit of the cobalt-base superalloys, since the data reported in this investigation indicate that the cobalt-tungsten-base alloys will be especially useful at very high temperatures. The moderately good fabricability of the cobalt-tungsten-base alloys should also increase their usefulness in superalloy applications.

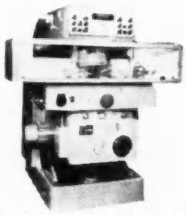
Certain cobalt-chromium-base alloys (casting alloys) have been used successfully as tool alloys and are considered superior to certain high-speed steels, but not as good as carbide tool materials. Their major advantages are exceptional resistance to wear, good hot hardness, and low coefficient of friction. Their main disadvantage is that they are appreciably weaker and somewhat more brittle than high-speed steels. Comparisons of the properties of one of the better cobalt-chromium-base alloys (Co-32%Cr-18%W-2·5%C-0·6%Mn, 0·4%Si) and of two promising cobalt-tungsten alloys, i.e., the binary Co-35%W alloy and the ternary Co-25%W-5%Mo alloy, show that the latter are considerably stronger and harder. Thus, the ultimate tensile strength of the Co-35%W alloy is 116,500 psi and of the Co-25%W-5%Mo alloy 107,000 psi, as compared with 65,000 psi for the cobalt-chromium-base alloy. Similarly, the hardness of the Co-35%W alloy ranges from 790 VHN at room temperature to 326 VHN at 900°C, and of the Co-25%W-5%Mo alloy from 719 VHN to 294 VHN, as compared with corresponding values of 640 VHN to 210 VHN for the cobalt-chromium-base alloy.

An important advantage of the cobalt-tungsten alloys is their ability to be hot-worked and machined in the solution-treated state. However, the potentialities of cobalt-tungsten-base alloys for tool applications must be investigated more thoroughly before any conclusive comparison can be made.

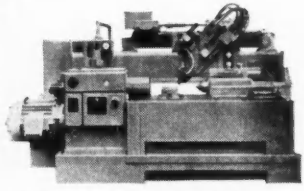
THE WINDOW ON THE WORLD OF MACHINE TOOLS



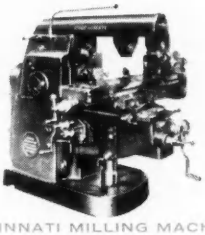
CHURCHILL MACHINE TOOL CO. LTD.



CHURCHILL GEAR MACHINES LTD.



CHURCHILL-REDMAN LTD.



CINCINNATI MILLING MACHINES LTD

By coming to Charles Churchill, the production planner can choose his complete requirements for the cold shaping of metal from the leading British, Continental and American ranges of machine tools. Through Charles Churchill's well-informed technical service he is kept in constant contact with all aspects of the industry.

If you are considering new production schemes, new or replacement machines for shaping, turning, grinding, boring, milling, planing or bending metal, consult Charles Churchill. They will be able to supply the quality machine tools you need . . . install and service them . . . advise you on their application and operation.

Make

CHARLES CHURCHILL

your window on the world of machine tools

Branches at: London, Manchester, Glasgow and Newcastle-upon-Tyne.

CHARLES CHURCHILL & COMPANY LIMITED
Coventry Road, South Yardley, Birmingham 25
Telephone: Acocks Green 2281

We have some unusual shots in our locker

but we are not taking over the function of the Royal Arsenal. Confidentially, all the components of this extraordinary weapon are nylon mouldings produced by us for various industrial uses.

Every week our design engineers assist some new client by producing a nylon moulding which, to-day, can replace a more conventional material and yet do its job more efficiently but usually costing less to produce.

A technical breakdown of this exclusive weapon is freely available to any discerning engineer with an eye to the future and—beautiful spies, please note that we are working in NYLON FOR ENGINEERS not nylons for the weaker sex.

Wragby Plastics do, of course, cover the whole field of thermo-plastics as well as nylon.

WRAGBY PLASTICS

THE PEOPLE FOR PLASTICS

Wragby Plastics Limited, Wragby, Lincoln. Wragby 383/4/5

WT/B.654

Progress in the Engineering Applications of Plastics

By W. C. G. MESSAM*

THE plastics industry was born in 1864, when an Englishman, Alexander Parkes, produced a material based on cellulose nitrate plasticized with camphor, which later became famous under the name of celluloid or xylonite. Although celluloid may be considered the pioneer plastic, it was, and still is, an extremely useful material. Indeed, were it not for celluloid film, it is probable that the development of motion pictures would seriously have been hampered.

In 1872, Baeyer showed that the interaction of phenol with formaldehyde yielded a hard resinous substance, but his experiments were not followed up until Swinburne and Baekeland began their investigations in the early part of the century. Production of this resinous material, subsequently known as Bakelite, started in 1909, and it may be of interest to note some of the most important developments in the brief history of the plastics industry since that date:—

1914 The first industrial use of cellulose acetate, or so-called non-inflammable celluloid.
1924 The discovery by Pollak, a Viennese chemist, of the condensation products of urea and formaldehyde.
1930 Initiation of research into the effects of high pressures on chemical reactions, leading to the discovery of polythene.
1935 Entry of acrylic resins into the market.
1937 Production of polyvinyl resins from both natural and cracked petroleum gases.
1938 Investigation into the reactions of di-isocyanates undertaken in Germany.
1940 First production of nylon.
1941 Commercial development of unsaturated polyester resins in the U.S.A., when casting resins were introduced.
1942 Introduction of allyl low-pressure casting resins.
1948 Commercial production of modern alkyd moulding materials in the U.S.A.
1950 Research both in Germany and the U.S.A., resulting in the introduction of high-density polythene.
1954 Stereospecific polymerization achieved by Professor Natta and his co-workers, leading to new classes of polymers characterized by exceptional regularity of structure, polypropylene being the first commercial application.

The plastics industry as a whole is fully aware of the increasing interest in the materials it produces and for which world demand is rapidly increasing. However, it is interesting to note that the introduction of new materials of vastly improved physical characteristics has not completely superseded the older materials. The demand for the older materials, however, has been considerably reduced and is now directed towards specialized applications.

The purpose of this paper is to survey the new materials, to discuss the advances which have been made in ancillary materials, and to describe some of the improvements which have resulted from their introduction.

The New Polymers

The great advances made in all aspects of plastics technology have been due to intensive and continuous research conducted all over the world, for it is from this research that the plastics industry has been able to develop its products to serve all branches of industry. This research, though often leading to general advances in technology, seldom results in the introduction of fundamentally new materials. However, in the last few years, several new polymers have been developed.

Polythenes and Polypropylene

For many years, Professor Ziegler in Germany has been associated with the chemistry of organo-metallic compounds and, more recently, with organo-aluminium compounds in particular. From his discovery and development of new methods for preparing these compounds there have been a number of spectacular results, of which the most significant has been that such compounds will react with derivatives of metals from Groups IV to VIII of the periodic table to form systems which catalyse polymerization of ethylene at temperatures in the range of 20 to 90°C, and at or near atmospheric pressure. At about the same time, Phillips Petroleum in the U.S.A. conducted research along similar lines.

The general outcome of this resesrch along parallel paths was the introduction of a new type of polythene, known as Ziegler or Phillips polythene, depending on the polymerization process adopted. This new material is now known as high-density or H.D. polythene, the description "high-density" distinguishing this new product from the low-density type of polythene already available, which has a specific gravity of about 0·92, whereas the specific gravity of the new materials varies between 0·94 and 0·96. In direct contrast to the low-density polythenes, which are polymerized at relatively high temperatures and pressures, the high-density polythenes are produced by catalytic polymerization at low pressure.

Shortly after the new polythenes were introduced, a new material, polypropylene, was developed. Polypropylene is the latest addition to the family of polyolefines, and its introduction was due to the work of Professor Natta and his co-workers on stereospecific polymerization, as already mentioned. The catalytic polymerization of propylene yields essentially linear polymer chains, which may possess either a regularly ordered or a random structure by varying the polymerization conditions or the catalyst system. The molecular structure affects the way the polymer crystallizes, which, in turn, affects the stiffness of the material produced.

Table I compares typical physical properties of the new high-density polythenes and polypropylene with the conventional low-density polythenes.

However, when comparing the properties of these types of materials, it must be remembered that for many

* Development Engineer, Spembly Ltd., Chatham, Kent.

TABLE I: COMPARISON OF POLYPROPYLENE, H.D. POLYTHENE, AND L.D. POLYTHENE

	Poly-propylene	H.D. Polythene	L.D. Polythene
Specific Gravity	0·90-0·91	0·94-0·96	0·92
Tensile Strength [psi]	4000-5200	2700-4200	1500-2200
Elongation [%]	400-900	160-600	200-600
Impact Strength [ft-lb/in.]	2·5-4·0	2-20	4-16
Shrinkage [in./in.]	0·010-0·025	0·015-0·040	0·015 - 0·050
Softening point [°C]	130-140	110-122	66-86
Coefficient of linear expansion	$1{\cdot}1 \times 10^{-4}$	$1{\cdot}3 \times 10^{-4}$	$1{\cdot}3 \times 10^{-4}$
Water absorption [%]	Nil	0·2	0·2

practical purposes their application is governed by their ability to withstand penetration by other substances. The tendency of such substances to penetrate into the material is directly related to the crystalline content of the material, the higher being the crystalline content, the less the penetrative weakness; thus, by raising the crystalline content, permeability is reduced and the resistance to solvents is increased. Polypropylene, with its higher softening point, offers better chemical resistance at higher temperatures than those tolerated by the thermoplastics normally used in the chemical industry, such as polythene and polyvinyl chloride (P.V.C.). In practice, a more important consideration than permeability is the so-called "stress-cracking effect", which is the tendency of a plastic material to crack when a stressed surface is exposed to certain liquids. In comparison with low-density polythenes, high-density polythenes generally show greater resistance to hydrocarbons and many other compounds. There are some compounds, however, which have a greater effect on high-density materials and, where a greater safeguard is required against the possibility of stress cracking, the use of a material with as high a molecular weight as possible is recommended. Tests made with polypropylene have revealed no embrittlement at all. The behaviour of these materials in sunlight is similar in that they are all susceptible to attack by ultra-violet rays. Components required for use under outdoor conditions should be made from materials pigmented with carbon black incorporating an anti-oxidant.

These new materials are more rigid than the conventional polythenes and are finding many applications hitherto considered outside the scope of materials of this type.

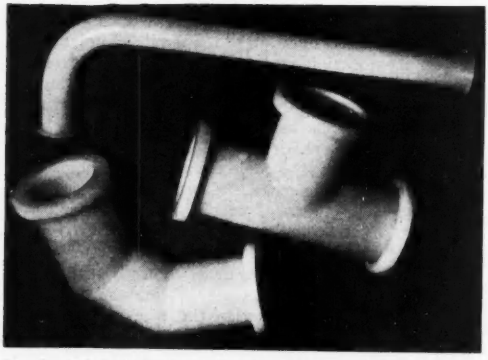


Fig. 1. Fabricated pipe and tube fittings in L.D. polythene.
(Courtesy of Bakelite Ltd.)

Fig. 2. Suction-strainer mouldings produced in H.D. polythene.
(Courtesy of British Resin Products Ltd. and Megator Pumps and Compressors Ltd.)

Fig. 3. Industrial truck wheel injection-moulded in H.D. polythene.
(Courtesy of British Resin Products Ltd. and Creators Ltd.)

For many purposes, polythenes in their normal forms are perfectly satisfactory, and no modification to the material is either necessary or desirable. Under certain conditions, however, although it may be desirable to use a material with the characteristics of polythene, polythene as normally available may not be suitable, owing to increased operating temperatures or the possibility of chemical attack. In such cases, irradiation of polythene has frequently been found to give a material of considerably wider application and longer useful life. Irradiated

materials have been commercially available both in Great Britain and the U.S.A. for the past few years.

The mechanism of the irradiation process may be simply stated as follows:—Each polythene molecule consists of long chains of carbon atoms to which are attached hydrogen atoms. The effect of high-energy radiation on this structure is to abstract some of the hydrogen atoms, leaving the molecule chemically unsatisfied. Two such unsatisfied molecules may then join together to form one larger unit, to which the same sequence of events may occur. In this way, a mass of polythene which formerly consisted of a very large number of molecules now has a much smaller number of larger molecules, entwined through each other and forming a network throughout the material.

The amount of cross-linking introduced into the polythene depends on the amount of radiation to which it is subjected. Since the effects of radiation are similar for both low-density and high-density polythenes, the process is equally applicable in both cases. Irradiation makes polythene less susceptible to stress cracking, and the normally well-defined melting point which occurs in the untreated material (about 130°C) is not so pronounced.

During the past few years, irradiated polythenes have emerged as a most satisfactory material for use in wire and cable insulation. Polythene containers for some of the more active stress-cracking agents, as used in cosmetic and pharmaceutical preparations, can have their life considerably extended by this means. Wash-bottles, laboratory tubing, and such items as grommets, bushes, O-rings, washers, and extruded seals stand up to hotter conditions and more rigorous service when so treated.

Figs. 1, 2, and 3 show three typical applications of low-density and high-density polythenes, which are available as moulding and extrusion compounds, and also in the form of rods, tubes, sheets, and complex sections. Their ease of fabrication, chemical resistance, toughness, and rigidity make them eminently suitable for use in connection with chemical plant, including ducting, hoods, effluent drains, and piping of all types, as well as for a large number of other industrial applications.

Polyamides

Polyamides are better known by the generic term "nylon", of which many types are in commercial production throughout the world. The properties of polyamides vary according to their type and composition, but, in general, are characterized by their strength, toughness, abrasion resistance, and excellent chemical resistance to most organic solvents.

The various types of nylon polymer are designated by numbers which do not refer to the number of carbon atoms in the connecting chains, but to the number in the starting material, e.g., nylon 6, nylon 66, etc. These types of nylon are well known and have made outstanding contributions in the field of mechanical engineering in the form of gearwheels, bushes, cams, bearings, and oil seals, as inserts in self-locking nuts, and in many other applications. In addition, nylon monofilaments are widely used in the manufacture of rope, and nylon fibres are well known in connection with the bristles used in the manufacture of brushes.

Nylon is readily available in the form of injection-moulding and extrusion compounds, and can be moulded with standard equipment. Some of the more interesting new applications of this range of materials are, however, in the form of crystalline powders mixed with inorganic additives which can be processed by cold-pressing and subsequent sintering, the production techniques used being somewhat similar to those employed in powder metallurgy. These materials are of interest where components of high quality are required, where internal strain must be at a minimum, and where high degrees of accuracy are essential. This material is available in the unfilled or natural state and also with graphite and molybdenum disulphide fillers, as well as in the form of porous mouldings which will absorb and maintain up to about 25% by weight of fluids and which are therefore ideally suitable for such applications as self-lubricated bearings, ink-rollers, etc. Nylon filled with molybdenum disulphide is readily available as rod, strip, tubing, and bar, and can be machined and used with great advantage in connection with the fabrication of conveyor parts and in many other applications where it is essential that friction between components must be reduced to a minimum.

Nylon tubing is now finding an increasing application in air lines, fuel lines, and oil pipelines, and is available in reinforced, semi-rigid, and flexible types in a wide variety of sizes, with different wall thicknesses, and weighing only about one-ninth of equivalent copper tubing.

Polycarbonate

A new thermoplastic material of considerable importance has been developed simultaneously in both the U.S.A. and Germany. Its name, polycarbonate, is derived from the carbonate linkage which joins the organic units of the polymer, and it is the first commercial material which incorporates the carbonate radical as an integral part of the main polymer chain, whose basic structure is similar to that of an epoxide resin. This material has a high degree of chemical resistance, particularly to hydrochloric, sulphuric, nitric, and phosphoric acids and petroleum products. It is a rigid material, and mechanical tests carried out on moulded components have confirmed its high strength characteristics, temperature resistance, excellent dimensional stability, transparency, and weathering qualities. The material has a high resistance to moisture and tests conducted on moulded components confirm that, during a period of ten days after moulding, the increase in weight, due to moisture, is of the order of 0·15%. The main physical characteristics of the material, compared with the characteristics of a typical nylon, are given in Table II.

TABLE II: COMPARISON OF PROPERTIES OF POLYCARBONATE AND NYLON

	Polycarbonate	Nylon
Specific gravity	1·20	1·14
Tensile strength [psi]	9000-10,500	8500-11,000
Elongation [%]	60-100	60-300
Impact strength [ft-lb/in.]	12-16	0·9-2·0
Shrinkage [in./in.]	0·005-0·007	0·020
Continuous temperature resistance [°C]	120-135	120-200
Coefficient of linear expansion	$0·7 \times 10^{-4}$	$1·0 \times 10^{-4}$
Water absorption [%]	0·3	1·5

The resin has negligible creep characteristics, and this, taken in conjunction with its transparency, dimensional stability, and resistance to deformation under stress, suggests its use in such applications as bushes, cams, gears, and other mechanical components. It has been used as a satisfactory replacement for brass in certain types of fluid pump, and its use for grommets,

nuts, and many other types of fastener is being investigated. Interest in rivet applications has been aroused by the susceptibility of the material to cold-heading.

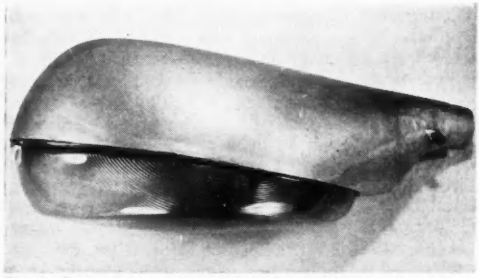


Fig. 4. Street-lamp cover, vacuum-formed from polycarbonate sheet material.
(Courtesy of R. H. Cole & Co. Ltd.)

As with other new materials, polycarbonate can be processed on existing equipment and can be used with moulding tools designed for nylon, polystyrene, etc. However, when compared with polypropylene and other materials, it becomes apparent that this new material, with its high impact strength, tensile strength, and elongation (approximately 50% less than that of polypropylene), will be used in a wide range of industrial applications, including uses for which diecast materials have hitherto been considered essential. Though its relatively high cost may restrict its development, it is undoubtedly a material which will become increasingly important during the next few years.

Polycarbonate is already being used for a wide variety of applications, especially in the form of lighting fixtures (Fig. 4), surgical appliances (Fig. 5), and mechanical parts, such as small gears.

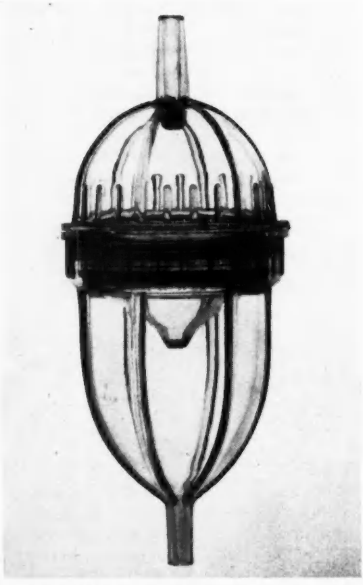


Fig. 5. Part of a blood-transfusion apparatus, injection-moulded in polycarbonate.
(Courtesy of R. H. Cole & Co. Ltd.)

Acetal Resins

Of the acetal resins, polyoxymethylene, a new thermoplastic material, was introduced by du Pont in America and became commercially available from a pilot plant during 1959. It is a tough, rigid material, having good mechanical properties, combined with a high resistance to temperature, dimensional stability, and resistance to deformation under highly stressed conditions. It is at present undergoing extensive development, Table III below outlining some of its major properties:—

TABLE III: TYPICAL PROPERTIES OF POLYOXYMETHYLENE

Specific gravity	1·425
Tensile strength [psi]	10,000
Elongation [%]	15-75
Impact strength [ft-lb/in.]	1·4-2·3
Continuous temperature resistance [°C]	185

Current tests on this material involve a number of practical trials of several applications which include components for the automobile industry, industrial packaging, and electrical equipment. The results so far are most encouraging. For example, in a ½-hp internal combustion engine, a timing gear performed successfully for 70 hr at a temperature of about 120°C without signs of wear. Speedometer gears moulded in this material have also shown high resistance to wear after 12,000 miles of practical use. It has also been used for other industrial applications such as trolley wheels, hinges, etc., and for many other components where toughness, coupled with resistance to stain, is of paramount importance.

Fluoroçarbons

The fluorocarbon resins, which have resulted from the development of fluorine, carbon, and chlorine compounds, have assumed a significant place in the plastics industry for the following reasons:—

(a) In general, they are capable of withstanding higher and lower temperatures than more complex resins.
(b) They are chemically inert to both acids and alkalis.
(c) As a group, they have excellent moisture-resistant characteristics.
(d) Their electrical properties are exceptional, polytetraftluoroethylene, in particular, being the only plastics material known in which the dielectric constant does not vary with temperature and frequency.

Although these materials are not new, development work is still intensive and, as new types of material emerge, so will their importance in industrial applications increase.

In common with other fluorocarbons, polytetrafluoroethylene (P.T.F.E.) has remarkable chemical inertness and stability. It consists entirely of carbon and fluorine and it is unique among synthetic high polymers in that it is attacked within its working temperature range (up to 300°C) only by molten alkali metals, which remove fluorine, and in certain circumstances by gaseous chlorine trifluoride and fluorine itself. It is not attacked by any normal chemical reagent, and no material is known which will dissolve it. It is unaffected by oxygen, ultra-violet light, or any combination of weathering conditions and is non-inflammable. Although, in thin films, it will transmit water vapour, it does not absorb and is not wetted by water. It has a very low coefficient of friction and freedom from sticking, good mechanical properties, and is readily machined; in particular, it is

tough and retains its flexibility at very low temperatures; a thin sheet, for example, will not crack when flexed in liquid oxygen.

Many applications, however, have been hampered by a peculiar physical property of P.T.F.E., which has jelly-like properties, exhibiting practically no flow and being mechanically weak above its transition point of 327°C, when it becomes completely amorphous. These factors combine to make the techniques of fabrication normally used for thermoplastic materials useless for P.T.F.E. The techniques used are akin to those employed in powder metallurgy, the general principle being to compact the powder into a preform of the desired shape and size, and then sinter it by heating above the transition point, at a temperature of 350 to 400°C.

Another type of polymer, polychlorotrifluoroethylene (P.C.T.F.E.) has been developed for use with standard injection-moulding equipment, and has physical characteristics, particularly insofar as heat, chemical, and electrical resistance are concerned, similar to those of P.T.F.E., but has a much higher tensile strength and is easier to fabricate, being a true thermoplastic. Some of the properties of P.T.F.E. and P.C.T.F.E. are summarized in Table IV.

TABLE IV: PROPERTIES OF P.T.F.E. AND P.C.T.F.E.

	P.T.F.E.	P.C.T.FE..
Specific gravity	2·1-2·3	2·1-2·3
Tensile strength [psi]	1500-3000	5700-7500
Elongation [%]	50-400	35-100
Impact strength [ft-lb/in.]	4·0	3·6
Water absorption [%]	<0·1	nil
Softening point [°C]	380-390	380-390

The low coefficient of friction of this range of polymers is one of the most important factors making this material particularly suitable for bearings, especially in the food-processing industry, where lubrication presents considerable problems.

The unique non-adhesive property of these resins particularly lends itself to the number of operations in which sticky materials are handled. Thus, by using it to cover the surfaces of processing equipment, such as conveyor belts, much of the time normally spent on cleaning is saved, there is less waste of materials, and operating efficiency improves.

In general, moulded sections are used when the surfaces are to be subjected to hard mechanical usage and may require periodic re-surfacing, where resilience is needed, or where, because of size or other considerations, it is not practical to apply a finish. A dispersion of P.T.F.E. is often used where a thin film (0·002 to 0·008 in. thick) is required over a metal substrate.

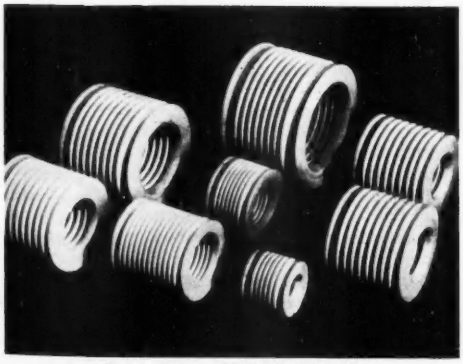


Fig. 6. Range of P.T.F.E. bellows.
(Courtesy of Crane Packing Ltd.)

Several new fluorocarbons have recently been developed, among them a copolymer of chlorotrifluoroethylene and vinylidene fluoride which is resistant to the attack of fuming nitric acid. Also, specially developed for spraying on small metal and ceramic parts, an aerosol-packaged chlorotrifluoroethylene polymer is now commercially available. Resins of low viscosity in the molten state are being used more and more for extrusion applications, and several grades are now available for spraying, dipping and other coating applications. One of the more recent applications of this material is illustrated in Fig. 6, which shows a range of bellows made of P.T.F.E.

Vinyl Plastics

Polyvinyl chloride (P.V.C.) is one of the older plastic materials and has been the subject of a great deal of research and development since it was first introduced. Its high chemical resistance has made it very popular in the chemical industry, where it is used in plant and fittings, but a number of new grades is now becoming available which will increase the growth of this aspect of the industry. Thus, chemical plant often requires vats and storage tanks whose service life, before the introduction of plastics, was short unless they were lined with glass or lead. P.V.C. is now used extensively for lining metal tanks, though the manufacture of these linings has, up to now, presented problems. The rigid grades of P.V.C. are the most chemically resistant and these present the biggest problems of fabrication and adhesion, but a new grade of P.V.C. sheet which overcomes these problems has recently been introduced and consists of two grades of P.V.C. of laminated construction. The side exposed to chemical attack is a rigid P.V.C. composition designed for maximum chemical resistance, while the reverse side is a plasticized relatively flexible composition specifically produced for use with adhesives.

The most interesting work done on P.V.C. is concerned with what is now known as high-impact rigid P.V.C., as distinct from rigid P.V.C. Some years ago, rigid P.V.C., sometimes called unplasticized P.V.C., came to be used more and more in the chemical industry for such purposes as tank linings, fume cabinets, extractor hoods, etc. The increase in production of this type of component was most noticeable on the Continent, particularly in Germany, but it soon became apparent that this type of material has very definite limitations when exposed to extremes of temperature and notably to low-temperature conditions. It was found that components were liable to considerable damage if subjected to shock loads at low temperatures, and great care had to be taken when unloading such items as pipes and effluent trunks, which could break if dropped during extremely cold weather. The first modification to the purely rigid material was the introduction of a small amount of plasticizer, which had the effect of reducing the hardness and slightly increasing the flexibility of the material. Further development has made it possible, however, to modify the polymer in such a way that it can be easily processed whilst maintaining a high degree of hardness and stiffness. The important feature of the material now produced is its extremely high impact strength, though this has been achieved by the sacrifice,

TABLE V COMPARATIVE PROPERTIES OF HIGH-IMPACT RIGID P.V.C. AND RIGID P.V.C.

	High-Impact Rigid P.V.C.	Rigid P.V.C.
Specific gravity	1·35	1·40
Tensile strength [psi]	6000	8500
Flexural strength [psi]	10,000	12,000
Izod impact strength [ft-lb/in.]	15·0	1·0
Heat-distortion temperature [°C] at a fibre stress of 264 psi	>70	>75
Softening point [°C]	>78	>82

to a slight extent, of tensile and flexural characteristics. An example of a component made of high-impact rigid P.V.C. is shown in Fig. 7. Some of the properties of high-impact rigid P.V.C. and of rigid P.V.C. are compared in Table V.

Fig. 7. Expansion unit for piping made of high-impact rigid P.V.C.

(Courtesy of British Geon Ltd.)

The vinyl family of plastics is of great importance in the industry, and large quantities of specific grades are used in engineering for chemical resistance and decorative finishes. The development of polyvinyl acetate resins in a new form has led to their increased use for paper and metal coatings, cements, and adhesives. Experiments with vinyl alkyl silicones in the U.S.A. have resulted in a temperature stability approaching 200°C. A new development has just been made known in which vinyl chloride/vinyl acetate copolymers used with glass rovings and liquid resins have been made to form coil springs which can replace metal springs in certain specific applications. P.V.C. sheeting is now well-known for its use as both industrial and domestic protective clothing, and in the nuclear-energy industry it is used in the form of pressurized suits to give protection against alpha radioactivity. Such a suit is made from two grades of sheet material and incorporates a P.V.C. harness which carries the necessary air control equipment. The control valves, though manufactured in metal, are coated with P.V.C. to simplify decontamination.

Silicone Resins

Silicone resins have been established for some years and are characterized by their temperature resistance, good electrical properties, and resistance to moisture. They are based on a long molecular chain structure consisting of alternate silicon and oxygen atoms and are related to such inorganic materials as glass and mica. Organic chemical groups, however, are attached to the silicon atoms and, by varying the basic silicon structure, as well as the attached organic groups, it is possible to modify the properties of these resins within certain limits.

Silicone resins are thermosetting materials, although certain types show a tendency to thermoplasticity at high temperatures. Polymers with thermoplastic characteristics have, however, been investigated, but so far have proved to be of little commercial value.

There are many different types of silicones available, such as fluids of varying viscosities and constitution, greases, rubbers, and resins for both laminating and bonding applications. It is proposed, however, to limit discussion to those compounds which have been recently introduced for moulding and laminating applications.

Of particular interest is a high-impact, glass-filled moulding compound currently available and suitable for use under short-time working conditions up to a temperature of 350°C. Further postcuring of the moulded component improves its physical properties, and components so treated have been subjected to service temperatures of 400°C. Some properties of this compound are given in Table VI. Components produced in this material are finding increasing use in connection with jet-engine and rocket-propulsion units and other applications of a similar arduous nature.

A range of recently introduced silicone rubbers, with a wide range of applications in the engineering field, is of particular interest in that they can be converted into heat-stable products at room temperature by the introduction of a small amount of liquid catalyst. By varying the amounts of catalyst it is possible, within limits, to predetermine the curing time. These rubbers, like other silicone compounds, can be used in the temperature range of −50 to +250°C and are suitable for the manufacture of flexible moulds, as a cushioning or caulking material, and as a release lining for moulds or belting. If subjected to temperatures above 300°C they will slowly decompose, leaving an inert, non-inflammable, and electrically non-conducting residue.

TABLE VI: PROPERTIES OF A HIGH-IMPACT GLASS FILLED SILICONE MOULDING COMPOUND

Specific gravity	1·65
Tensile strength [psi]	
at 23°C	12,000-14,000
at 200°C	5000-6000
Impact strength [ft lb/in.]	11-15
Heat distortion point [°C]	500
Coefficient of linear expansion	8×10^{-6}
Water absorption [%]	0·10-0·13

Probably the most important contribution of silicones to the plastics industry is in their use as resinous bonding materials for producing glass- and asbestos-reinforced laminates, which are used particularly in connection with the electrical, electronics, and aircraft industries. Silicone-glass laminates have shown good resistance to short-time exposure to temperatures of 550°C and have been used for components situated near to the exhaust systems of jet aircraft. A further interesting application has been in connection with aircraft radomes. Owing to the increasing speed of aircraft, radomes manufactured in this material are showing greater resistance to frictional heat, a factor which is very important in aircraft design.

Epoxy Resins

Epoxy resins are recognized as being among the toughest and most durable of the plastic materials and can be used for many purposes, particularly for casting and tooling. Liquid polyamide resins have become available, and it has been found that a thermosetting solid resin results from their reaction with epoxides. It has also been discovered that the proportions of polyamide and epoxide are not critical and, if varied, will produce

Fig. 8. Fairing for the canopy of a fighter aircraft, moulded in a glass-reinforced phenolic compound.
(Courtesy of Bakelite Ltd. and H. Comoy & Co. Ltd.)

epoxy/polyamide resin compositions with widely differing physical properties. This combination of resins has been of great significance in both adhesives and tooling.

Reinforced Plastics

Plastic moulding compounds tailored to suit specific applications have been available for many years, and it has been possible to obtain phenolic and other moulding materials in which fillers have been introduced to enhance the characteristics of the resin. For example, to improve electrical properties, mica can be added, while rag or cotton fibres improve toughness and overall strength; to increase thermal resistance and strength, asbestos fibres are used.

However, with the introduction of glass fibre a material became available which, when used as a reinforcing medium, conferred on resins a substantial increase in mechanical strength, stiffness, impact resistance, and dimentional stability. Silicone, alkyd, and phenolic moulding compounds with glass fibre as a reinforcing medium are available for use with conventional compression moulding tools, but the main limitations which these materials present to a design is that the minimum wall thickness is about $\frac{1}{16}$ in. for optimum strength. Other problems, however, can arise when wall thicknesses exceed $\frac{1}{2}$ in. An example of a component made of a glass-reinforced phenolic compound is shown in Fig. 8.

With the introduction of polyester and epoxide resins the range of structural applications has increased, both these resins being thermosetting materials available in liquid form. A physical change of state is introduced by hardener systems, which differ in nature according to the resin with which they are used. When the hardener is added to the resin, a reaction is brought about which is exothermic in character. The result of the reaction is that the resin is polymerized or cured and becomes an infusible solid. These resins can be cured without pressure, and will produce a constructional material which, when allied to a suitable reinforcement, has outstanding strength/weight characteristics. Enhanced chemical, electrical, or other properties which may be required can be obtained by using other types of resins, silicone, melamine, phenolic, and thermosetting acrylic resin formulations being now available. There are many possible combinations of glass and resin, all being light in weight, possessing good physical properties, and suitable for the production of large dimensional mouldings with relatively low tooling costs. Components can, however, be produced from matched metal moulds in considerable quantities with very little variation in dimensional tolerances.

The material made by glass rovings used in conjunction with these resins can be subjected to tensile loads approaching 200,000 psi, and research and development have produced a wide variety of reinforcing fabrics and mats which help to solve the design problems of "built-in" strength with the minimum of "tailoring". A system of three-dimensional weaving of glass fibre has been developed in America and is now also available in Britain. This system produces a consistent reinforcement in the shape of "socks" which can be pulled over a male mould, and thus, by weaving to a specific shape, the costly tailoring of a reinforcement is eliminated. In addition to reducing costs, a further advantage is the great improvement in the quality of the finished moulding. The manufacture of radomes is an example of the value of this method, for by any other system their production is costly, allied to a relatively high reject rate.

One factor of great importance to the designer using these materials is that, owing to the linear characteristics of the load/elongation curve, a working stress near the breaking stress of the material can be used. There is no yield point, as is associated with steel, for example, and thus it has been known for certain components to be

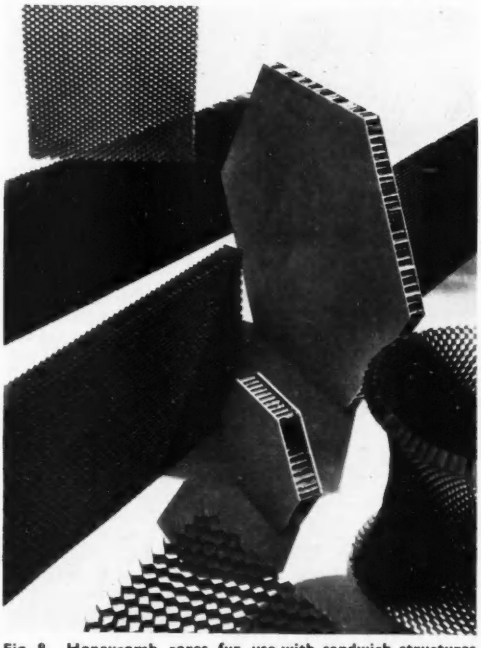


Fig. 9. Honeycomb cores fur use with sandwich structures.
(Courtesy of British Resin Products Ltd.)

stressed in excess of 75% of the ultimate stress with sstisfactory results. Another important factor is that, for certain resin reinforcement combinations, it is possible to obtain better fatigue characteristics than those associated with steel. Typical applications which make full use of the strength/weight characteristics of these materials are monocoque chassis/body construction for automobiles, boat hulls up to a length of 65 ft, and bulk-packaging containers.

When various forms of glass reinforcement are used with epoxy and polyester resins, the material lends itself particularly to the fabrication of sandwich structures. In comparison with metallic materials, glass-fibre laminates are not unduly rigid, and stiffness can be increased by using laminated skins over cores of such materials as balsa wood, foamed plastics (cellulose acetate, polystyrene, phenolic, or polyester) or honeycombs (aluminium, phenolic-impregnated paper, or glass laminates), as shown in Fig. 9. The strength/weight ratio of such constructions is finding increasing favour with aircraft manufacturers, and they are being used for many secondary structures. There is no doubt that research now being undertaken will lead to their adoption for primary structures in the near future.

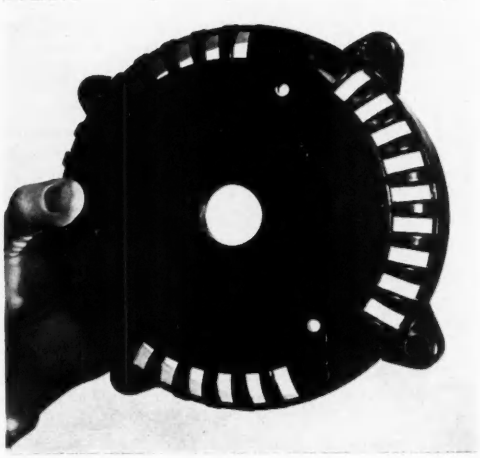


Fig. 10. Brush cover made from a dough moulding compound. *(Courtesy of British Resin Products Ltd. and Minerva Mouldings Ltd.)*

Dough moulding compounds, comprising a polyester resin heavily filled with chopped glass fibre, and other fillers such as calcium carbonate, are becoming increasingly important in the solution of production problems by the use of conventional compression moulding equipment. An example of a component made with a dough moulding compound is illustrated in Fig. 10.

Adhesives

Since the early 1930's, the adhesives industry has expanded rapidly, as a result of the introduction of synthetic resins, which, apart from any other advantages over earlier types of animal or vegetable adhesive have excellent resistance to moisture and to mould growth. Also, many synthetic-resin adhesives based on the same material often exhibit a wide variation of properties, this being due to the catalysts, fillers, plasticizers, etc., which may be added to impart specific characteristics.

Synthetic-resin adhesives can be divided into two main groups, one of which includes adhesives for use in structural applications, i.e., in continuously stressed structures, while the other consists of non-structural adhesives for unstressed applications. For stressed components, temperature requirements are of considerable importance and the main adhesives for this type of application are based on epoxy resins, epoxy-polyamide resins, phenolic-epoxy resins, and phenolic-nitrile, phenolic-neoprene, phenolic-polyamide, and phenolic-vinyl compounds. Certain of these compounds are suitable for temperatures of 300 to 500°C, but others weaken very rapidly at temperatures in excess of 200°C.

Epoxy Resins

Epoxy resins are thermosetting materials which are cured by the addition of various types of hardeners. They can be cured at room temperature, but higher strengths and better heat resistance can be obtained when the adhesive is heat-cured. Heat-curing may also considerably reduce the curing time, also depending upon the type of hardener used. With unmodified epoxy adhesives, shear strengths may be obtained up to 3000 psi, but they have low flexibility and poor impact strength. Their great advantages are low volume shrinkage, no evolution of volatiles during cure, and the fact that only contact pressure is required. They have excellent insulating properties and are useful for gap-filling applications, the thickness of the glue line being from 0·001 to 0·012 in.

Several new types of hardener have recently been introduced, particularly in the sphere of epoxide resins. Amine hardeners were the agents used originally for promoting cure of the liquid resins, but their main disadvantages were their irritant potential and the comparatively low temperature resistance of the cured resin. The introduction of anhydride hardeners has had a marked effect on the temperature resistance of a fully cured epoxide resin, and, with new resins based on different chemical systems, compositions can now be obtained with a resistance in excess of 250°C.

Epoxy-Polyamide Resins

The versatility of epoxy adhesives is increased by the addition of polyamide (nylon) resins to improve their flexibility. These adhesives have better resistance to impact and mechanical shock, and have a longer pot life, so that they are somewhat easier to use. They cure at room or slightly elevated temperatures and, owing to the thermoplastic nature of the polyamide resin, they are more sensitive to temperature changes than are the unmodified epoxies. Typical shear-strength values, with aluminium-to-aluminium bonds, are about 3000 psi at room temperature, dropping to about 500 psi at 250°C.

Phenolic-Epoxy Resins

Phenolic-epoxy resins constitute one of the most promising types of adhesives for metals suitable for service at continuous temperatures of up to 260°C and higher. For service at high temperature these resins require heat-curing. Shear strengths of up to about 3000 psi at room temperature reduce to from about 1000 to 2000 psi at 260°C.

Phenolic-Nitrile Compounds

Certain blends of nitrile (acrylonitrile-butadiene) synthetic rubbers, when allied to certain phenolic resins, form one of the few types of adhesive suitable for the

structural bonding of metals. They require heat-curing at temperatures up to 260°C under pressures up to 200 psi, and possess shear strengths of 4000 psi and higher, good impact strengths, and resistance to cold flow. Minimum service temperature is about −50°C. Adhesives of this type are used for a wide variety of applications, one particular example being their use for bonding linings to brake-shoes.

Phenolic-Neoprene Compounds

Phenolic-neoprene compounds produce versatile adhesives suitable for bonding a variety of materials, but are inferior generally to the phenolic-nitrile compounds. They are heat-cured at pressures up to about 500 psi, a stronger bond being obtained by curing at about 260°C. Shear strengths of up to 2000 psi are possible, with good resistance to flow and fatigue. The incorporation of isocyanates improves their adhesion to some surfaces.

Phenolic-Polyamide Compounds

Blends of these resins have been specially developed for bonding metals for high-temperature applications, especially in aircraft structures. Shear strengths of 5000 psi at room temperature and over 3000 psi at 150°C are obtainable. Heat-curing is required under pressure for optimum results.

Phenolic-Vinyl Compounds

Certain phenolic and vinyl compounds have formed one of the most successful types of structural adhesive for metal-to-metal bonding, especially in aircraft construction. Polyvinyl formal is the resin usually employed, but polyvinyl butyral is also used. A well-known adhesive of this type is available in two parts, with the phenolic resin as a liquid and the polyvinyl formal as a powder. The assembly is heat-cured under pressure, and room-temperature shear strengths of 5000 psi are obtainable. There is no significant weakening at temperatures up to about 85°C, but the strength of the bond deteriorates rapidly at about 120°C, when the adhesive begins to soften. The minimum service temperature is about −57°C.

These adhesives are finding increasing use in the structural bonding of metals, and also for bonding metals to plastics, such as copper foil to laminates for the manufacture of printed circuits.

New Processes and Equipment

New and improved materials give rise to new and improved techniques, plant, and equipment. The oldest form of moulding technique is that known as compression moulding, and is used for producing components in thermosetting compounds such as phenolic, melamine, urea, silicone, and so on. By 1935, injection-moulding machines became increasingly important in performing the same task for thermoplastic materials, such as cellulose acetate, polystyrene, P.V.C., cellulose acetate butyrate, nylon, and polythene. Comparatively recently, a new system known as vacuum forming was introduced for producing components from thermoplastic sheet

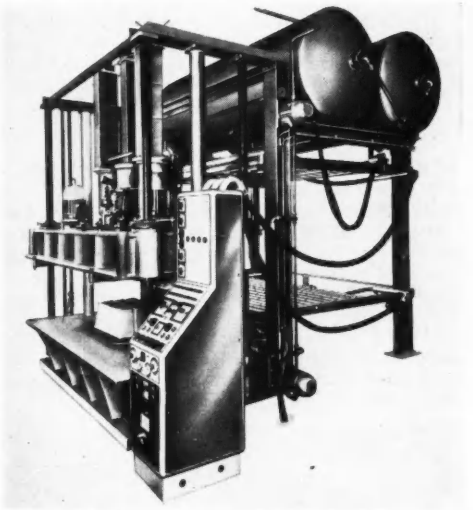


Fig. 12. Large-capacity vacuum-forming machine.
(Courtesy of Richard Hall Ltd.)

material. This technique has proved suitable for manufacturing many different items, ranging from packaging and advertising displays, to liners for refrigerators. As components have increased in size, new equipment has naturally had to be designed to meet requirements, two examples of which are illustrated in Figs. 11 and 12.

Coating with Plastics

As interest in the manifold applications of plastics increases, the engineer will be the first to realize that in certain cases they may give a new lease of life to materials which have been used for centuries. This rejuvenation has already occurred in the chemical industry, where metal parts of pumps exposed to chemical attack have had their lives considerably extended by coating with plastics.

The method of coating metal parts with P.V.C. plastisols is not new. A plastisol paste is a viscous fluid of a complex nature, consisting of polymer, plasticizer, pigments, fillers, and stabilizers. By varying the ratio of plasticizer to polymer, degrees of hardness ranging from approximately 30° Shore to 95° Shore can be obtained. As a result of considerable research, a wide range of

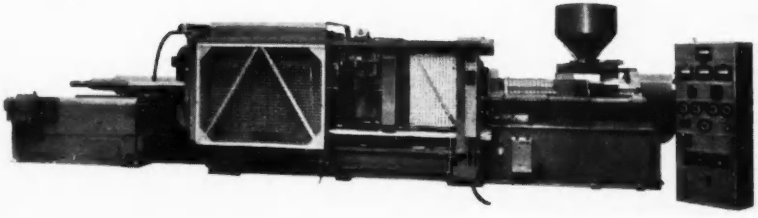


Fig. 11. "Peco" Model 60.MP.60 injection-moulding machine with in-line preplasticizer and a shot capacity of 60 to 90 oz and a locking force of 750 tons.
(Courtesy of Projectile and Engineering Co. Ltd.)

materials with various flow characteristics is now available for coatings and for use with different coating techniques. Dipping or spraying are the normal methods of application, but, taking advantage of the flexibility of P.V.C. materials, an interesting method of moulding components on a male tool has been developed. Using this system, moulded components with a double curva ture, impossible to reproduce by other methods, can be made. A new technique for moulding components with sections up to $\frac{1}{2}$ in. in thickness, using a simple matched tool and curing by R.F. heating, is now being developed. This method will give a hardness range up to 120° Shore and, in comparison with the present technique for producing similar components, a saving in production costs of about 90%.

Some of the more interesting developments now taking place concern the coating of metal with plastics. When coating with P.V.C. plastisols, the metal substrate is first cleaned, then coated with a primer if an adhesive coating is required, after which the substrate is heated and finally dipped into the plastisol. The temperature of the substrate when dipped and the period of time allowed in the plastisol determine the thickness of the coating. The final process is to withdraw the component from the paste and cure it in an oven.

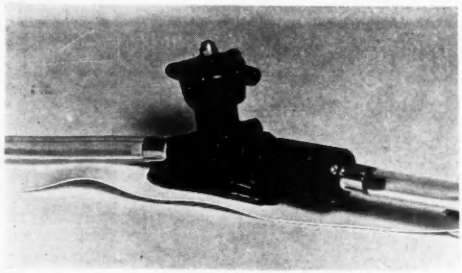


Fig. 13. Low-pressure air control valve of metallic construction coated with P.V.C.
(Courtesy of Spembly Ltd.)

The tremendous impact that plastics have made in the field of surface coatings may not be generally realized, as a very large proportion of industrial finishes are now resin-based, one example being shown in Fig. 13. Modifications to existing polymers have increased the number of materials becoming available for a new method of coating known as the "fluidized-bed technique", in which, instead of using a liquid plastisol in a tank, a fine powdered polymer is made to behave like a liquid by passing air through the bed of the vessel in which it is contained. The powder, like a mist, is held in suspension in the air, and the heated component is lowered into this fluidized bed. Thin-section components may require subsequent heat treatment, but on most components this can be dispensed with. The main advantage of this technique is that, whereas the plastisols used for dipping are P.V.C.-based, other types of material can be used in the fluidized bed, e.g., H.D. and L.D. polythene, cellulose acetate, cellulose acetate butyrate, and nylon. Polypropylene and epoxy resins are now being developed for use with this process. Some of the better-known coating applications using the fluidized-bed technique include electrical insulations, wear-resistant coatings, handwheels, etc., but it is expected that such items as stirrers, fan-impellers, electroplating jigs, cable trays, and tool handles will soon be added to the list. Typical applications are shown in Fig. 14.

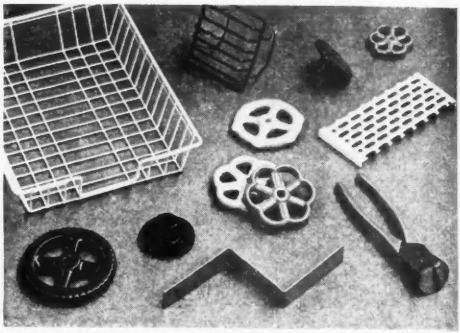


Fig. 14. Articles coated with different materials by the fluidized-bed technique.
(Courtesy of The Telegraph Construction and Maintenance Co. Ltd.)

A product of major importance recently introduced and now being developed is a resin specially prepared for surface coating and soluble in water. Unlike existing water-based products, this resin will provide a hard and durable surface comparable with that obtained with the better-quality oil-bound paints at present on the market.

Surface finishes based on polyurethane resins have also made their appearance and are becoming increasingly popular for coating surfaces exposed to severe weathering. These finishes are two-part mixes, i.e., a liquid hardener has to be added to the compound. Three applications are needed, the first being a primer coat, the second a colour coat, and the third a transparent coat to give depth of gloss. Each coat "cures" rather than dries; in fact, heat during this curing cycle impairs its physical properties and has an overall detrimental effect on the finished product.

Plastic Tooling

With the introduction of glass-fibre-reinforced polyester and epoxy resins, the advantages of using this type of material for moulds, particularly those for low-pressure laminates, were soon realized. Developments, using filled resins, sometimes in conjunction with other fillers, have produced compounds with a wide variety of properties. The introduction of glass-fibre produced material of high tensile strength, and the use of aluminium and iron powder have resulted in ductile solids with a reasonable heat conductivity, while fillers such as sand have vastly improved compression characteristics. For certain applications it is possible to use a skin of glass-fabric-reinforced resin and to support the

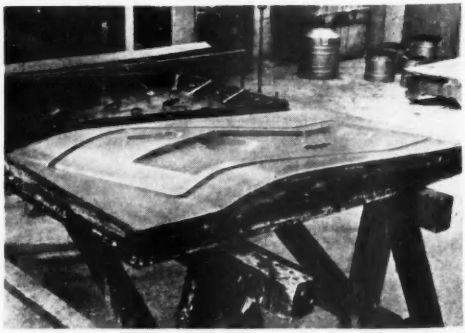


Fig. 15. Filled epoxy-resin die for producing a pressed steel door panel.
(Courtesy of Cornelius Chemical Co. Ltd.)

shape with a filled-resin mixture. The use of such fillers in bulk not only improves certain characteristics but also reduces costs.

Realization of the unlimited scope of these constructional methods has led to plastics tooling, a new industry which, though comparatively small, is growing rapidly. Plastics tooling has already established itself in many industrial applications by virtue of such advantages as speed in producing tools, accuracy, and the elimination of complex machining, with a consequent reduction in costs.

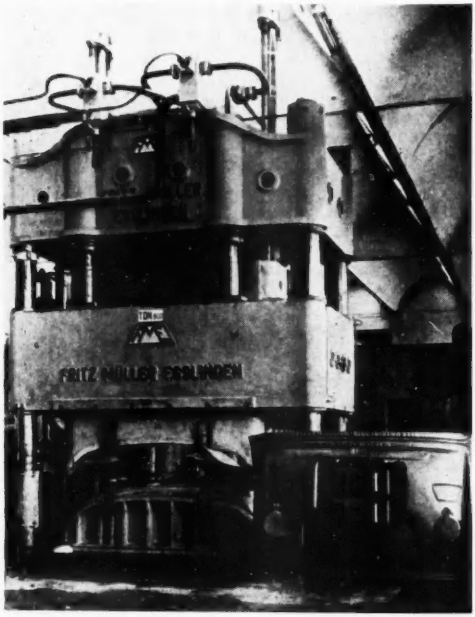


Fig. 16. A large sheet-forming press, utilizing a reinforced-plastic press tool, for producing front panels for 10-ton lorries.
(Courtesy of Cornelius Chemical Co. Ltd.)

This type of tooling is being used for the construction of duplicate models, for checking and assembly fixtures, pantograph and copy-milling models, foundry patterns and core boxes, and metal-forming press tools (Fig. 15). Reinforced-plastic metal-forming tools are suitable for use during the production of short- or medium-length runs of pressings in light-gauge stainless steel, 18-s.w.g., mild steel, or aluminium alloys, the number of pressings that can be obtained being directly related to the severity of the processing operation. In this connection, it may be of interest to note that more than 10,000 pressings in 20-s.w.g. mild steel have been obtained from such tools, and no doubt, as development continues, tools capable of producing much larger quantities will be designed. A large press, using an epoxy press tool for producing the front panel of 10-ton lorries in the works of an Italian manufacturer is illustrated in Fig. 16.

With regard to foundry patterns, it should be noted that, by absorbing moisture, conventional wooden foundry patterns have a tendency to warp, especially if stored in damp conditions, are easily damaged by rough handling, and have a low temperature resistance, while metal patterns, though probably the most durable, take a long time to make and are expensive to manufacture. On the other hand, cast-resin patterns, using fillers, are quickly made, have excellent dimensional stability, and good resistance to abrasion. In addition, they are from 60 to 80% lighter than corresponding metal patterns, resist corrosion, and can easily be repaired if damaged accidentally.

The vacuum forming of thermoplastic sheet, in itself a simple operation carried out on relatively cheap equipment, requires cheap and quickly produced moulds. Plastic resin moulds can be produced more quickly and cheaply than metal moulds, and they provide a high-gloss surface which does not mar the softened and sometimes highly polished thermoplastic sheet formed against the surface of the mould.

The cost and materials used in tools made for the production of components by the injection-moulding process must, like any other form of tooling, be considered in relation to the number of components to be produced. Using epoxy resins, selected hardener systems, and metallic fillers, it is now possible to manufacture cheap tools specially suitable for development purposes and short-run production. As always, the life of a tool depends on the conditions under which it is operated, but it is possible for it to produce quantities of more than 5000. Tools made with these resins cost approximately 80% less than their equivalent made of metal.

Spray Moulding

Reinforced plastics offer great advances over many forms of conventional constructions because of their ease of fabrication, strength, and the fact that styling can be "built-in". Mouldings in this medium are normally made by a rather primitive method in which catalysed liquid polyester resins are applied with a brush and the resin made to impregnate the reinforcing fabric by a "stippling" action, using brushes and rollers. Recently, however, the spraying of resin and glass has become a practical possibility. The first commercially available spray-moulding machines appeared about three years ago, but a simplified unit has now been developed which has great advantages, a typical spray unit being shown in Fig. 17.

The spraying of glass fibre and resin saves a great deal of processing time, and the equipment illustrated will

Fig. 17. A glass-fibre-resin spray unit in use for spraying a 7 ft 6 in. dinghy hull.
(Courtesy of Lawrence & Erasquin Ltd. and John Trundell Ltd.)

materials with various flow characteristics is now available for coatings and for use with different coating techniques. Dipping or spraying are the normal methods of application, but, taking advantage of the flexibility of P.V.C. materials, an interesting method of moulding components on a male tool has been developed. Using this system, moulded components with a double curvature, impossible to reproduce by other methods, can be made. A new technique for moulding components with sections up to $\frac{1}{2}$ in. in thickness, using a simple matched tool and curing by R.F. heating, is now being developed. This method will give a hardness range up to 120° Shore and, in comparison with the present technique for producing similar components, a saving in production costs of about 90%.

Some of the more interesting developments now taking place concern the coating of metal with plastics. When coating with P.V.C. plastisols, the metal substrate is first cleaned, then coated with a primer if an adhesive coating is required, after which the substrate is heated and finally dipped into the plastisol. The temperature of the substrate when dipped and the period of time allowed in the plastisol determine the thickness of the coating. The final process is to withdraw the component from the paste and cure it in an oven.

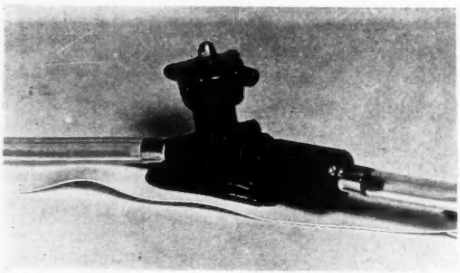


Fig. 13. Low-pressure air control valve of metallic construction coated with P.V.C.
(Courtesy of Spembly Ltd.)

The tremendous impact that plastics have made in the field of surface coatings may not be generally realized, as a very large proportion of industrial finishes are now resin-based, one example being shown in Fig. 13. Modifications to existing polymers have increased the number of materials becoming available for a new method of coating known as the "fluidized-bed technique", in which, instead of using a liquid plastisol in a tank, a fine powdered polymer is made to behave like a liquid by passing air through the bed of the vessel in which it is contained. The powder, like a mist, is held in suspension in the air, and the heated component is lowered into this fluidized bed. Thin-section components may require subsequent heat treatment, but on most components this can be dispensed with. The main advantage of this technique is that, whereas the plastisols used for dipping are P.V.C.-based, other types of material can be used in the fluidized bed, e.g., H.D. and L.D. polythene, cellulose acetate, cellulose acetate butyrate, and nylon. Polypropylene and epoxy resins are now being developed for use with this process. Some of the better-known coating applications using the fluidized-bed technique include electrical insulations, wear-resistant coatings, handwheels, etc., but it is expected that such items as stirrers, fan-impellers, electroplating jigs, cable trays, and tool handles will soon be added to the list. Typical applications are shown in Fig. 14.

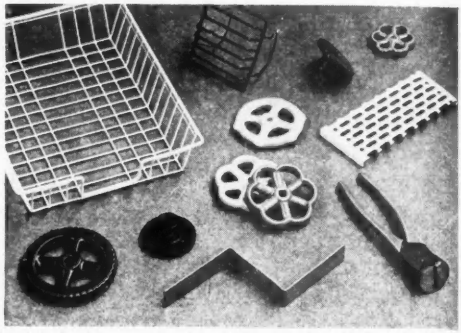


Fig. 14. Articles coated with different materials by the fluidized-bed technique.
(Courtesy of The Telegraph Construction and Maintenance Co. Ltd.)

A product of major importance recently introduced and now being developed is a resin specially prepared for surface coating and soluble in water. Unlike existing water-based products, this resin will provide a hard and durable surface comparable with that obtained with the better-quality oil-bound paints at present on the market.

Surface finishes based on polyurethane resins have also made their appearance and are becoming increasingly popular for coating surfaces exposed to severe weathering. These finishes are two-part mixes, i.e., a liquid hardener has to be added to the compound. Three applications are needed, the first being a primer coat, the second a colour coat, and the third a transparent coat to give depth of gloss. Each coat "cures" rather than dries; in fact, heat during this curing cycle impairs its physical properties and has an overall detrimental effect on the finished product.

Plastic Tooling

With the introduction of glass-fibre-reinforced polyester and epoxy resins, the advantages of using this type of material for moulds, particularly those for low-pressure laminates, were soon realized. Developments, using filled resins, sometimes in conjunction with other fillers, have produced compounds with a wide variety of properties. The introduction of glass-fibre produced material of high tensile strength, and the use of aluminium and iron powder have resulted in ductile solids with a reasonable heat conductivity, while fillers such as sand have vastly improved compression characteristics. For certain applications it is possible to use a skin of glass-fabric-reinforced resin and to support the

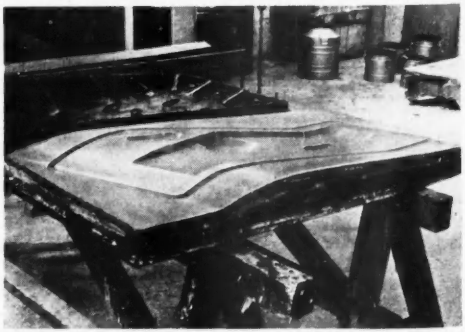


Fig. 15. Filled epoxy-resin die for producing a pressed steel door panel.
(Courtesy of Cornelius Chemical Co. Ltd.)

shape with a filled-resin mixture. The use of such fillers in bulk not only improves certain characteristics but also reduces costs.

Realization of the unlimited scope of these constructional methods has led to plastics tooling, a new industry which, though comparatively small, is growing rapidly. Plastics tooling has already established itself in many industrial applications by virtue of such advantages as speed in producing tools, accuracy, and the elimination of complex machining, with a consequent reduction in costs.

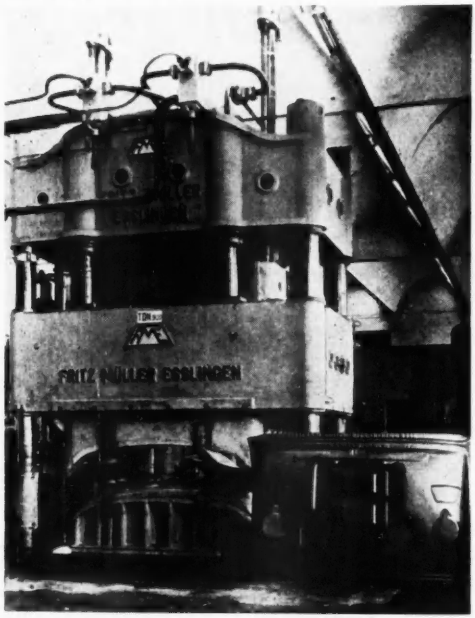


Fig. 16. A large sheet-forming press, utilizing a reinforced-plastic press tool, for producing front panels for 10-ton lorries.
(Courtesy of Cornelius Chemical Co. Ltd.)

This type of tooling is being used for the construction of duplicate models, for checking and assembly fixtures, pantograph and copy-milling models, foundry patterns and core boxes, and metal-forming press tools (Fig. 15). Reinforced-plastic metal-forming tools are suitable for use during the production of short- or medium-length runs of pressings in light-gauge stainless steel, 18-s.w.g., mild steel, or aluminium alloys, the number of pressings that can be obtained being directly related to the severity of the processing operation. In this connection, it may be of interest to note that more than 10,000 pressings in 20-s.w.g. mild steel have been obtained from such tools, and no doubt, as development continues, tools capable of producing much larger quantities will be designed. A large press, using an epoxy press tool for producing the front panel of 10-ton lorries in the works of an Italian manufacturer is illustrated in Fig. 16.

With regard to foundry patterns, it should be noted that, by absorbing moisture, conventional wooden foundry patterns have a tendency to warp, especially if stored in damp conditions, are easily damaged by rough handling, and have a low temperature resistance, while metal patterns, though probably the most durable, take a long time to make and are expensive to manufacture. On the other hand, cast-resin patterns, using fillers, are quickly made, have excellent dimensional stability, and good resistance to abrasion. In addition, they are from 60 to 80% lighter than corresponding metal patterns, resist corrosion, and can easily be repaired if damaged accidentally.

The vacuum forming of thermoplastic sheet, in itself a simple operation carried out on relatively cheap equipment, requires cheap and quickly produced moulds. Plastic resin moulds can be produced more quickly and cheaply than metal moulds, and they provide a high-gloss surface which does not mar the softened and sometimes highly polished thermoplastic sheet formed against the surface of the mould.

The cost and materials used in tools made for the production of components by the injection-moulding process must, like any other form of tooling, be considered in relation to the number of components to be produced. Using epoxy resins, selected hardener systems, and metallic fillers, it is now possible to manufacture cheap tools specially suitable for development purposes and short-run production. As always, the life of a tool depends on the conditions under which it is operated, but it is possible for it to produce quantities of more than 5000. Tools made with these resins cost approximately 80% less than their equivalent made of metal.

Spray Moulding

Reinforced plastics offer great advances over many forms of conventional constructions because of their ease of fabrication, strength, and the fact that styling can be "built-in". Mouldings in this medium are normally made by a rather primitive method in which catalysed liquid polyester resins are applied with a brush and the resin made to impregnate the reinforcing fabric by a "stippling" action, using brushes and rollers. Recently, however, the spraying of resin and glass has become a practical possibility. The first commercially available spray-moulding machines appeared about three years ago, but a simplified unit has now been developed which has great advantages, a typical spray unit being shown in Fig. 17.

The spraying of glass fibre and resin saves a great deal of processing time, and the equipment illustrated will

Fig. 17. A glass-fibre-resin spray unit in use for spraying a 7 ft 6 in. dinghy hull.
(Courtesy of Lawrence & Erasquin Ltd. and John Trundell Ltd.)

reduce production costs considerably and will almost eliminate the wastage of material which occurs with "bucket-and-brush" techniques. A three-fold reduction in labour costs is a reasonable estimate for most small to medium-sized mouldings of simple structure, while more complex shapes benefit to an even greater extent. For instance, it has been estimated that, in the moulding of a 16-ft boat hull, labour costs can be reduced to as little as 20% of those incurred by normal moulding techniques. Owing to the short fibre length of the reinforcing material and the method of production, the strength of the material produced by the spraying technique is approximately 25% less than that produced by conventional methods, but this can be compensated by a 5% to 10% increase in thickness. Despite this increase in thickness, however, a component produced by the spray technique still shows a remarkable saving in labour costs. In addition, the wet-strength retention of materials produced by the spray technique is higher than that of materials produced by conventional methods.

The Future of Plastics

There is no doubt that plastic materials are being, and will be, used in ever-increasing quantities for engineering applications, but there is one major obstacle yet to be overcome if the fields of these applications are to be greatly enlarged. The problem is to provide a substance which, while having the other inherent properties common to plastic materials generally, can be used in a much wider temperature range. At low temperatures, many materials tend to become brittle to such an extent that, for a reduction of 50°C below room temperature, the impact strength can, in certain circumstances, be reduced by over 80%. At high temperatures, e.g., above 200°C, thermoplastics will soften and will not retain their shape. Thus, at the present moment, it is left to thermosetting materials to provide an answer to this problem.

Plastic materials are organic compounds and, apart from their thermal stability, are generally bad conductors of heat and electricity. Chemists have long dreamed of making inorganic polymers and elastomers which will retain the stability and conductivity of some of the simple inorganic materials and, at the same time, possess the same characteristics of plasticity and elasticity common to so many of the organic materials, their use for special purposes in high-speed aircraft and missiles being an example. Interest in the whole range of inorganic polymers is increasing, and recent reports have shown that polyphosphates with high molecular weights can be prepared and should therefore result in interesting polymers. It has also been found that elastomers may be prepared from mixed sodium and potassium, cross-linked with calcium ions and plasticized with water.

Research in the field of inorganic polymers is showing great promise, as elastomers have been prepared which have relatively stable thermal characteristics, even in the region of 500°C. First reports indicate that progress has been made in forming compounds which withstand temperatures up to 300°C and have melting points at around 480°C. In long-term research and development projects in both Europe and America, it is planned to study various polymers at temperatures as high as 1500°C. Nevertheless, it is not only the problem of temperature that is the subject of research, as a great deal of effort is being directed towards such characteristics as, for example, abrasion resistance, weathering, transparency, and toughness.

INDUSTRIAL MOULDINGS (WARWICK) LIMITED

Suppliers of trade mouldings in thermo-plastic and thermo-setting materials, very many of which have suitable applications in the engineering field.

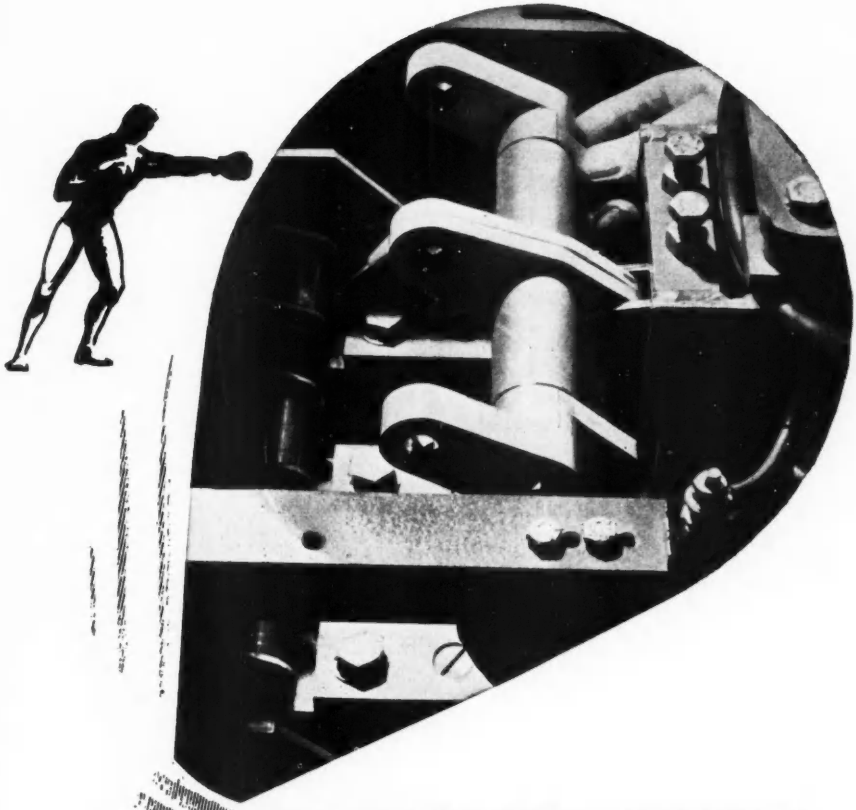
Enquiries invited:

write to us at:—

EMSCOTE, WARWICK

or phone:—

WARWICK 987-8-9



ROCKITE DMC

can take it!

High impact strength and excellent insulation properties are just two of the reasons why Rockite DMC is used for the moulded bases and operating links of the 'HAS 2T' heavy duty Air Circuit Breaker. Asta tests prove that Rockite DMC mouldings withstand the large magnetic throw-off force inherent in making a current of 110,000 Peak Amps, and take the heavy blows of the 10 lb Moving Contact Assembly without fracturing. Rockite DMC permits improvements in design . . . fewer loose parts . . . greater clearance between live parts and earth . . . the manufacture of each base as a single pole assembly. Thus Rockite DMC is ideal for insulators, motor housings, instrument panels, heat ducting, heavy load bearing switchgear . . . in fact for tough jobs in any industry.
For details of Rockite DMC, write for Booklet No. 121 TODAY.

'HAS 2T' Air Circuit Breaker is made by J. G. Statter & Co. Ltd., Amersham Common, Bucks; mouldings by Minerva Mouldings Ltd., Raans Road, Amersham, Bucks, using Rockite Dough Moulding Compound.

Rockite is a reg'd 'rade mark

British Resin Products Ltd A COMPANY IN THE DISTILLERS PLASTICS GROUP BRP

SALES & TECHNICAL SERVICE DEVONSHIRE HOUSE PICCADILLY LONDON W1 HYDE PARK 0151

Distillers Plastics Serve Everyman

the book that has taken **thirty-five years** to produce

. . . it embodies the experience of 35 years as specialist manufacturers of gland packings.

Over the years we have produced a number of catalogues of our range of gland packings, each one more informative than its predecessor. **But this latest publication breaks entirely new ground.**

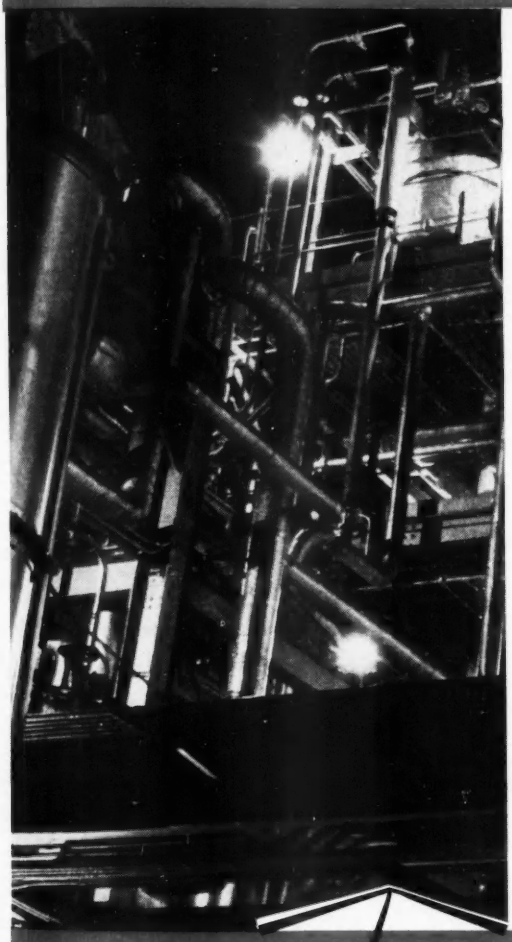
It is the most comprehensive reference book to the use of gland packings ever produced anywhere in the world.

In the space available here it is impossible to describe all the contents, but we will send to you, *free of charge and postage paid*, a copy of the publication. **Please write to Crane Packing Limited, Gland Packings Division, Slough, Bucks.** *If you require the publication to be addressed personally to you, please let us have your name and address, the name of your Company and your position in the Company.*

ISSUED BY THE GLAND PACKINGS DIVISION OF

Crane Packing LTD OF SLOUGH ENGLAND A 71 COMPANY

Bakelite have the right materials for industry



In the factories of Bakelite Limited are produced many of the plastics raw materials vital to industry today. In the laboratories, research and development chemists are constantly at work improving existing materials and developing others which will play an equally important role in the future. Among the materials manufactured by Bakelite Limited are—

BAKELITE Phenolic moulding materials
Alkyd moulding materials
Laminated sheet, rod and tube
Glass laminates
Densified wood, compregnated wood
Copper clad laminates
Adhesives and cements
Surface coating resins, foundry resins
Polyester resins, epoxide resins

VYBAK PVC extrusion compounds
Injection moulding compounds
Calendered sheet and film
Rigid and flexible pressed sheet
Compounding and calendering resins
Surface coating resins

WARERITE Decorative laminated veneers, Wallboard, pictorials

SHALON Monofilaments

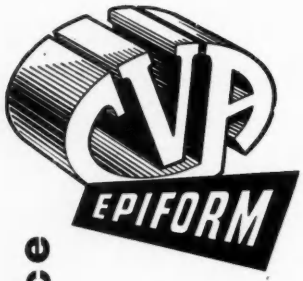
SLOane 0898

Bakelite Limited

12-18 GROSVENOR GARDENS LONDON SW1

The trefoil symbol and the words BAKELITE, VYBAK, WARERITE and SHALON are registered trade marks of Bakelite Limited

TGA BVW11A/1



formulated resins

a complete plastics tooling service

press tools
jigs
checking fixtures
gauges
routing templates
foundry patterns
core boxes
vacuum forming moulds
drop hammer dies
stretch dies
rubber bed tools
keller patterns
welding fixtures
spinning chucks
double-action draw dies

Broad acceptance of the use of plastics resins for tooling has resulted from the introduction of epoxy resins. The best results can only be obtained by careful formulation.

KEARNEY & TRECKER C.V.A. LTD. are accredited formulators of EPIFORM resins appointed by Shell Chemical Co., Ltd.

EPIFORM resins are well suited to this tooling programme on account of

high dimensional accuracy
high compressive strength
high impact strength
good resistance to abrasion and corrosion
absence of cold flow
good adhesion to metal inserts and lifting bolts

Compared with metals, EPIFORM resin tools possess the advantages of

reduced cost of manufacture
reduced time of manufacture
reduced weight
ease of manufacture
ease of modification and repair
lower toolroom equipment investment

CVA undertake the complete manufacture of plastics tooling, the supply of formulated materials with a full technical advice service on EPIFORM methods and applications.

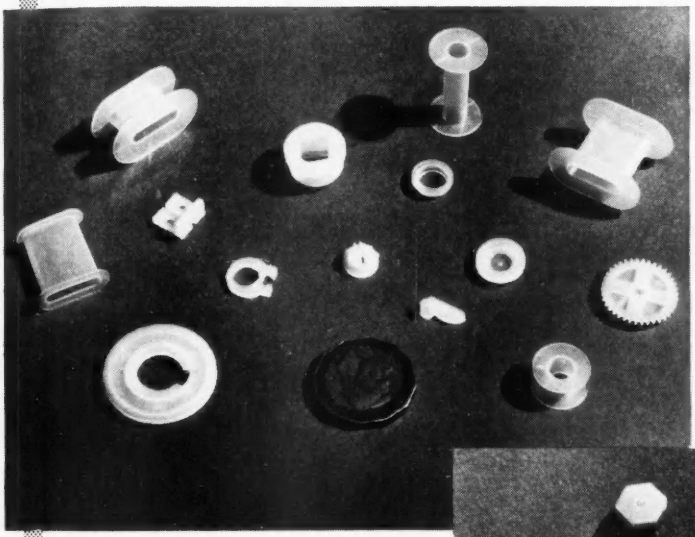
Write for literature to:—

E. H. JONES (MACHINE TOOLS) LIMITED
GARANTOOLS HOUSE · PORTLAND ROAD · HOVE · SUSSEX
Telephone: HOVE 47253 *Telegrams: Garantools, Portslade*

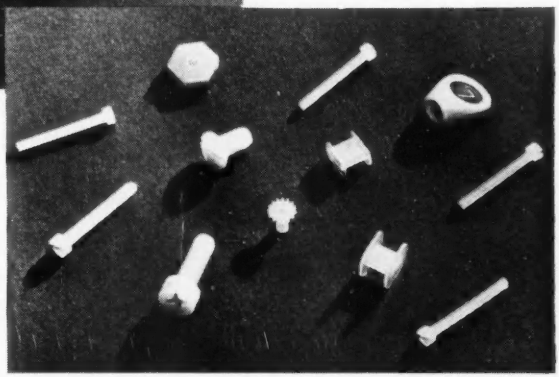
LONDON · BIRMINGHAM · GLASGOW · MANCHESTER · BRISTOL

NAP 2848

Today's engineers are using the material of tomorrow—'Maranyl' A 100 nylon



Selection of screws and components moulded in 'Maranyl' A 100 nylon by George Goodman Ltd., Robin Hood Lane, Birmingham, 28.



Screws and components made from 'Maranyl' A 100 nylon are light in weight, corrosion resistant and good electrical insulators

THE SCREWS and components illustrated were moulded in 'Maranyl' A 100 nylon by George Goodman Ltd., Robin Hood Lane, Birmingham, 28. They are light yet strong, resistant to corrosion and are good electrical insulators. They are long-lasting and resist vibrational fatigue and abrasion.

There are many other important features of this I.C.I. plastic that commend it for a multitude of uses in the industry of today—and tomorrow. It resists oil, fuel, greases and most common solvents. It needs no lubrication. Its inertia is low. It is easy to fabricate. It has low coefficients of friction and is silent in operation. 'Maranyl' A 100 nylon is available in a wide range of colours.

I.C.I. RESEARCH AND TECHNICAL SERVICE

'Maranyl' A 100 nylon is backed by the full force of I.C.I. Research and Technical Service. That service is available to you. If there is anything you wish to know about nylon and its uses; if you have a problem concerning noise, lubrication, wear and durability—consult I.C.I. They will be glad to help.

'Maranyl' A 100 NYLON

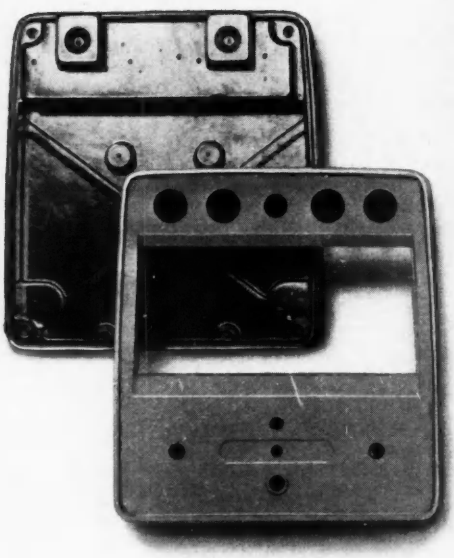
'Maranyl' is the registered trade mark for the nylon compound manufactured by I.C.I.

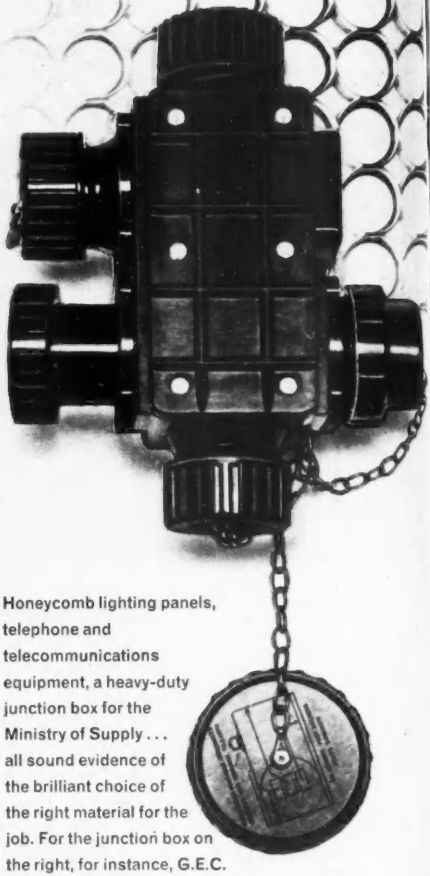
ICI

IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1

PN 155

LIGHT AND SOUND





Honeycomb lighting panels, telephone and telecommunications equipment, a heavy-duty junction box for the Ministry of Supply . . . all sound evidence of the brilliant choice of the right material for the job. For the junction box on the right, for instance, G.E.C. experts chose chopped cotton fabric-filled phenolic material to stand up to the roughest outdoor applications.

The G.E.C. moulding shops, among the largest in the country, make possible this versatility in production. They are equipped to handle any industrial job within the full thermoplastic and thermosetting range. Behind them is the accumulated wisdom of 40 years of experience.

If it's moulded plastics you need, rely on the experience of G.E.C.

THE GENERAL ELECTRIC COMPANY LIMITED OF ENGLAND
MOULDED PLASTICS DIVISION BIRMINGHAM 6

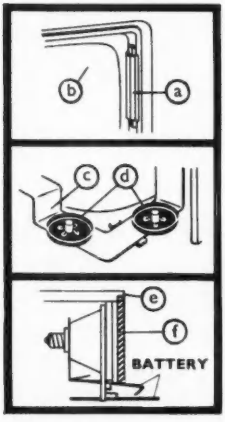
TAKE A GOOD VIEW!

18 mouldings - just one fixing screw

The wedge (a) holds the lens (b) in position securely, yet allows for minor alignment adjustments.

Electrical contact slips (c) are attached by metal fasteners (d) which clip over plastic pins.

The overlapping ledge (e) holds the slide (f) in position and simultaneously completes the electric circuit.



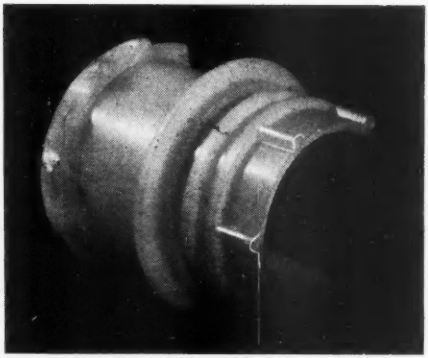
Keen on photography? Next time you pass a photographic shop look at this brilliant, new, colour-viewer by Johnsons of Hendon Ltd. As a photographer you will appreciate its undoubted efficiency and the advantages of its variable magnification. The ingenious arrangement for holding the slide in position also closes the electrical circuit to provide illumination without resort to finger-pressure or a switch.

As a plastics engineer or user, you will be impressed by the superlative finish of the two-colour injection mouldings, the single fixing screw and the unique way the lenses have been secured. We co-operated in the design, made the tools, produced the mouldings and handled assembly and packaging. Our associate company the British Optical Lens Co. designed and produced the glass lens system.

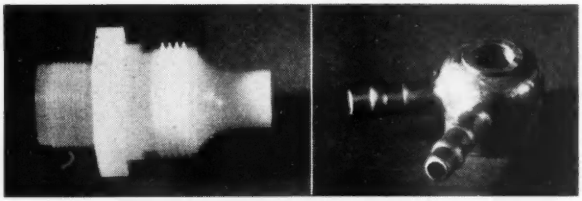
E. Elliott Limited

The plastic moulders with the engineering background
315 SUMMER LANE, BIRMINGHAM 19
Telephone: ASTon CROSS 1156/7/8/9

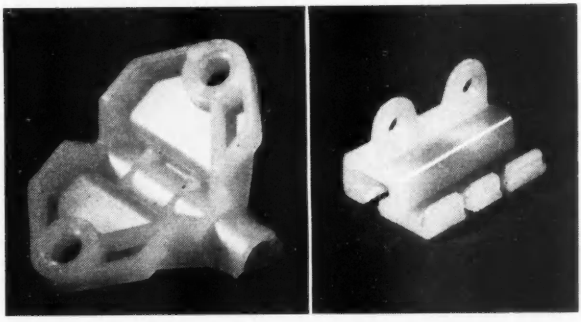
it's the



NYLON



KNOW-HOW



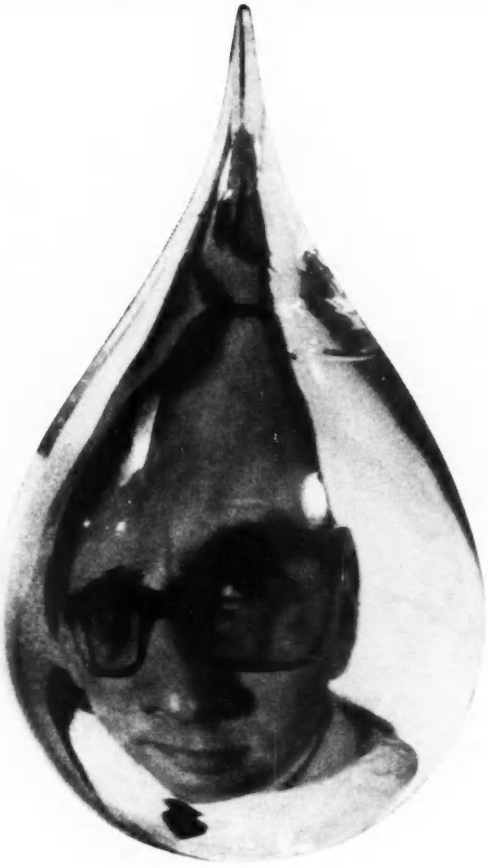
that counts . . .

to produce mouldings of quality and precision. Our extensive experience is at your service in dealing with nylon moulding projects.

MOULDED PLASTICS (B'HAM) LTD.
REDDICAP TRADING ESTATE
SUTTON COLDFIELD WARKS.

SUTTON COLDFIELD
6677 & 7100

mp



LOOKING FOR FLUIDS—with exceptional thermal stability—fluids that are water-repellent and retain good dielectric characteristics over a wide range of temperatures — that resist oxidation—have low volatility and show little change in viscosity with temperature –are ideally suitable for use in damping mechanisms—as heat transfer media—and for use in hydraulic, springing and coupling devices—GET THEM FROM MIDLAND SILICONES.

Remember – Midland Silicones Ltd. have consistently set the pace for British progress in this fast developing field. Remember, too, that – while silicones cost more initially, this extra outlay is more than offset in terms of greater efficiency and long term economy.

MS **MIDLAND SILICONES LTD**

(Associated with Albright & Wilson Ltd and Dow Corning Corporation)

***first** in British Silicones*

68 KNIGHTSBRIDGE · LONDON · SW1 TEL: KNIGHTSBRIDGE 7801

Area Sales Offices : Birmingham · Glasgow · Leeds · London · Manchester · Agents in many countries

The full range of MS silicone fluids is described in detail in our new 'Engineering Guide to MS SILICONE FLUIDS.' Just complete the coupon and we'll be glad to send you a copy.

NAME .....

COMPANY .....

ADDRESS .....

.....

MSFIa

TUFNOL

IS HARDWEARING

Here is a laminated plastics material that thrives in conditions where other materials fail. TUFNOL withstands rough treatment; resists corrosion; gives excellent service immersed in seawater, mild acids and alkalies, petrol and oil, and it will not be attacked by rodents or pests. Have you a problem of production, maintenance or design? Ask our Engineer to come and talk TUFNOL with you.

STRONG BUT LIGHT
RESISTS CORROSION
WITHSTANDS CLIMATIC EXTREMES
ELECTRICAL INSULATOR
MACHINES EASILY
STORES INDEFINITELY

TUFNOL

(REG. TRADE MARK)

Available in sheets, tubes, rods, angles and channels in numerous brands

TUFNOL LTD · PERRY BARR · BIRMINGHAM 22B

388

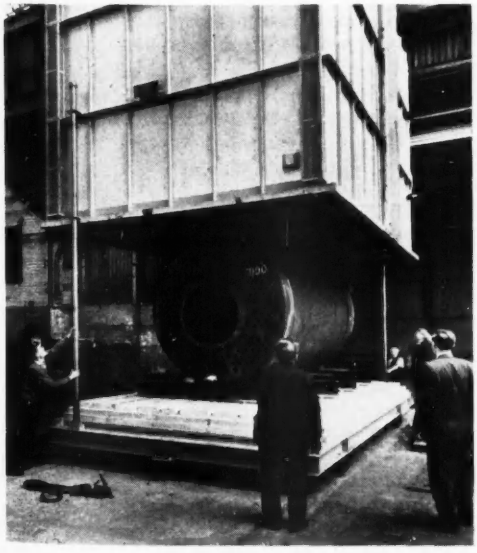
British Industrial Developments

Large "Top-Hat" Stress-Relieving Furnace

Designed and produced by Shelley Electric Furnaces Ltd. in co-operation with the South of Scotland Electricity Board, a new furnace installed and now in operation at the Glasgow boiler works of John Thompson (Wilson Boilers) Ltd. is the largest electric "top-hat" furnace in the world to be used for stress-relieving. The furnace, which has been installed to speed up production of the company's "Multipac" and "Demipac" boilers, has a maximum load size of 17 × 11 × 11 ft, and can therefore handle boilers and pressure vessels up to 11 ft in diameter, as well as other welded structures within these dimensions. The maximum weight loading is 15 tons, though this can be exceeded where a period of more than 9 hr is available to heat a given load. The heat-treatment cycle is 9 hr to 650° C, a soak of from 1 to 3 hr being required, followed by natural cooling for 12 hr.

The furnace is stated to be a new development in electric heating, inasmuch as it has an extremely high efficiency because of the low thermal mass of its insulating structure. In addition, it can attain temperature uniformity rapidly, enabling it to be fired in less than 12 hr, using the night-time off-peak electricity tariff. The furnace has an electrical loading of 360 kW and is fully automatic, requiring no attention, other than initial setting and starting. Full instrumentation is incorporated, and the furnace easily holds its temperature of 650° C for the required period within very close limits.

The heating elements have a life expectancy of several years and are fitted on all four sides, the base, and the top, thereby ensuring temperature uniformity with all types of loads. The elements are controlled in three zones by automatic programme controllers, these zones being respectively the base, all four walls up to two-thirds of the height from the base, and the top, extending one-third of the way down the walls to meet the second zone. The furnace cools by radiation in 12 hr, so that it is capable of handling seven loads per week.



The hearth has been built as a bogey for convenience, and can be loaded with a boiler on either of two bays by a crane. The cover is then lowered over the load by a crane, as shown in the illustration, in which the furnace can be seen in the process of being lowered over a "Multipac" boiler. Finally, the furnace is pushed into a third bay, where it automatically engages the electrical supply for firing.

Portable Belt Conveyor

Claimed to be the most versatile ever offered to industry, the new "Standard" portable belt conveyor produced by Numec Ltd., of New Whittington, Chesterfield, is a development of the recently introduced Numec "Cadet" portable conveyor, but has a considerably increased maximum capacity, i.e., 110 tons per hour, as compared with 75 tons per hour for the "Cadet". A feature of the "Standard" conveyor is that the elevating arms are controlled hydraulically, so that, with a simple adjustment of the boom angle, there is an infinite range of boom positions, including penetration below ground level. In addition, a reversing gear has been fitted, enabling the belt to run in either direction.

The conveyor incorporates specially made belting with corrugated sides, 2 in. in height. The belt, which can be operated at a maximum speed of 220 fpm, is 16 in. in width and is also fitted with cross-bars, 8 × 1¾ in. at a pitch of 20 in. With this type of belt, the conveyor can easily handle powder, granulated materials, bulk grain, sand, coal and coke, bricks, clay, concrete, sacks, cases, etc. A specially designed hopper can be attached for loading loose materials, and the hopper capacity can be increased by the addition of detachable extension pieces.

A 320-cc petrol engine is used for driving the conveyor, the drive being totally enclosed in the elevating arms. The height with the boom vertical can be varied between 2 ft 8 in. and 8 ft 7 in., and the maximum working angle, with one end of the boom on the ground, is 45 deg. The overall weight of the conveyor is 31 cwt, so that it can be easily towed by any conventional vehicle, while its overall width of only 6 ft 4 in. facilitates negotiation of any route. In operation, the two towing arms can be folded back.

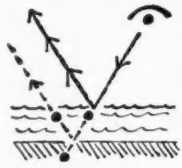
Electrostatic Dust-Measuring Equipment

An accurate and continuous indication of the rate at which air is being polluted by chimney gases can now be obtained by means of new electrostatic dust-measuring equipment developed by the Electronic Apparatus Division of Associated Electrical Industries Ltd., of New Parks, Leicester. The new equipment eliminates the disadvantages of previous methods of determining the quantity of solid matter carried in chimney gas. For instance, the gravimetric method gives periodic indica-

Infra-Red Heating

Infra-red heating is the name given to the method of using, in industrial processes, radiant heat from heaters specifically designed for that purpose. This differentiates it from methods employing both radiation and convection, as in furnaces, although the effect of the radiation is much the same in both cases.

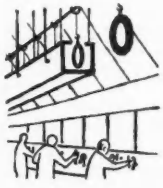
Radiant heat provides a higher rate of heat transfer to bodies not highly reflective than does convection, unless high-velocity forced convection is used. The rate of heating of a body depends on the intensity of radiation on its surface, the proportion absorbed by the surface and, after that, on heat conduction.



In heating very thin bodies, for example paint films, the radiation not reflected nor absorbed passes through and is in turn reflected or absorbed by the underlying material. This reflected heat is partly absorbed by the paint film "on the way back". Despite this effect infra-red gives mainly a surface heating effect except in the case of a few special applications.

Infra-red heaters mainly use metal-sheathed elements in special reflectors, but infra-red lamps with internal reflectors are still used in special cases. Other types use silica-sheathed elements or quartz-sheathed lamps in reflectors. A wide range of heaters is available with simple mounting arrangements to enable heat to be applied quickly and effectively either in a production line or in some odd corner.

Control of the charge temperature is effected by regulating the heating time and power. In the case of a moving charge, this is done by adjusting the conveyor speed and the number of heaters in circuit, i.e. by adjusting the effective length of the oven. Some of the heaters may be controlled by energy regulators or adjustable transformers.



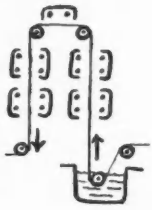
The advantages of infra-red heating over convection heating include reduced heating times, reduced floor space, lower installation costs, almost instant starting, ability to focus the heat, and flexibility in effective oven length. Infra-red ovens can often be mounted in the roof, saving valuable floor space. Infra-red heating is not generally favourable for heating large bodies of low heat conductivity.

Paint Stoving

Many paints, particularly synthetic enamels, and including synthetic wood finishes, are well suited to infra-red heating, and many products ranging from small components to complete motor cars are being successfully stoved. Infra-red heating reduces stoving times very considerably and often improves the finish.

Moisture Extraction

Infra-red can provide high drying rates, either of liquid surface films or of thin absorbent materials. Sheathed element heaters usually give the highest rates, but lamps are sometimes used where the dried material is particularly heat-sensitive. Applications include such tasks as drying of paper and textile products, bottle seals and labels, clayware glazes and many others.



Plastics

Infra-red is widely used in the plastics and allied industries for such typical applications as softening and curing of plastic sheets and belts, heat setting of nylon and similar fabrics, drying and curing of plastic and rubber coatings and others where a plastic forms the whole or part of a product.

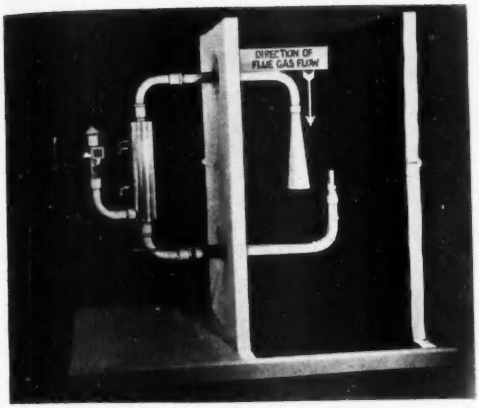
The above are just a few examples of successful applications of infra-red. In many other processes infra-red heaters can often be fitted quickly and cheaply, to save time, labour and floor space and, therefore, money.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books on electricity and productivity (8/6 each, or 9/- post free) are available—"Resistance Heating" is an example; "Induction and Dielectric Heating" is another.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

8131/2



tions, using a measured sample of the polluted gas which is filtered and the retained deposit then weighed, while the optical method measures the surface area of dust by means of a beam of light projected through the duct or chimney and, in principle, responds to dust area per cubic foot, rather than to the area emitted per second. For this reason, any measurement of density by optical methods must be related to flue-gas velocity if true indications are to be given of the rate at which the atmosphere is being polluted.

The A.E.I. system, which is mounted in the flue as shown in the illustration, overcomes the velocity-dependence disadvantage of the optical method by automatically taking into account the product of particle number, velocity, and area. This is achieved by providing a corona environment in a continuously flowing sample of the gas, where all solid particles become charged, each in proportion to its surface area. The charged particles continue to move downstream and in aggregate form a current which is proportional to the product of particle number, velocity, and area. After amplification, this current can be used to operate a warning device if the rate of pollution should exceed a preset value and to indicate and record pollution rates. In this way, duct conditions as they change with boiler operation can be faithfully recorded, including start-up periods and flame failures.

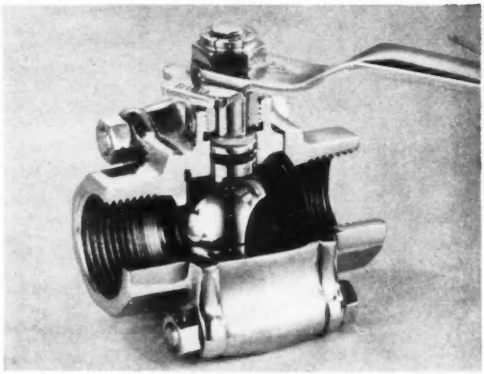
Hydraulic Actuator for Diesel-Engine Revolution-Counters

As announced by Wm. Coulthard & Co. Ltd., of Carlisle, a new method, of simple design and with no maintenance problems, has been developed by the British Manzel Oil Pump Co., of Carlisle, for operating the revolution-counters of Doxford diesel engines and has successfully completed a 1000-hr test on a Doxford "P"-type engine. Since this test, it has also been fitted to a number of engines in various motor vessels.

Essentially, the assembly comprises a pump unit, housed in a steel container and operated by means of a normal type of Doxford lubricator with a lever working on an eccentric fixed to the camshaft for driving the cylinder lubricators. Every rotation of the eccentric gives an impulse of oil, which is pumped through a small-bore copper pipe to the counter actuator mounted on the revolution-counter at the engine control station. The oil impulse operates a plunger, tripping the counter mechanism, after which the plunger is retracted by a spring, automatically returning the oil to the pump unit, ready for the next power stroke. During the power stroke, more oil is pumped than is actually required to effect the movement. This surplus provides a safe working margin of oil, which is diverted back to the reservoir via a relief valve set to a predetermined working pressure and which can clearly be seen through a transparent sight feed dome.

Ball-Valves

Known as the "Econ-O-Miser" in the U.S.A., where it has been marketed for many years by the Worcester Valve Company Inc., of Worcester, Mass., a ball-valve now being introduced into the U.K. by the Worcester Valve Company Limited, of Burgess Hill, Sussex, is available in a range of eight sizes, from $\frac{1}{4}$ to 2 in. An outstanding feature of the valve is that it serves both as a valve and a union and, as it is designed with detachable pipe ends which replace costly flanges, it is extremely easy to service. All that is necessary is to remove four nuts and slide out the four bolts, after which the entire centre section can be lifted right out, enabling the seats and O-rings to be replaced quickly and the valve returned to the line.



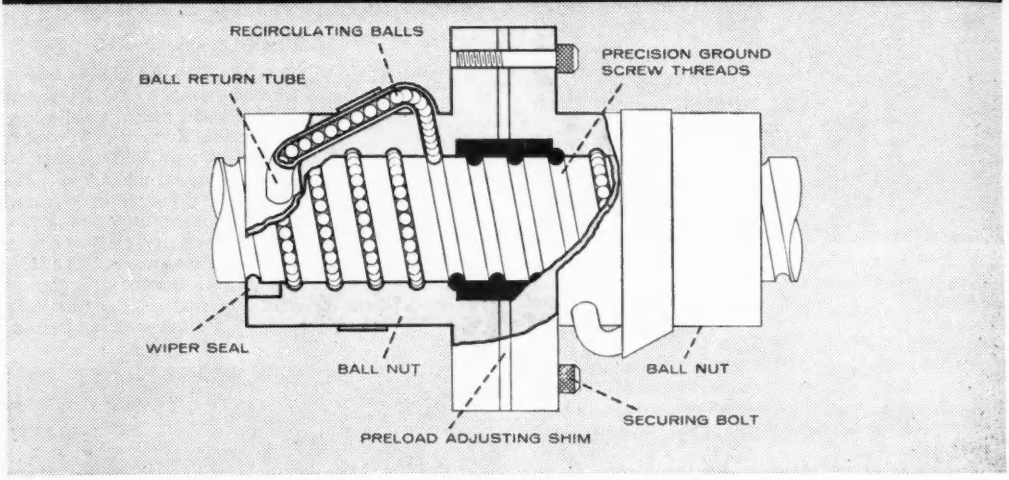
Although the ball-valve principle is not new, recent developments in design and in seat and seal materials make it an excellent replacement for most on/off valves currently used in the process industries and suitable for the solution of most media problems. Thus, the valve is available in bronze, carbon steel, and stainless steel, while a variety of seat materials, including synthetic rubber, nylon, and P.T.F.E., enable the valve to be used as a replacement for gate, flanged-gate, diaphragm, and lubricated plug valves.

Electro-Chemical Elapsed-Time Indicators

A series of compact, electro-chemical elapsed-time indicators of basic American design has been introduced by Industrial Instruments Ltd., of Richmond, Surrey, for recording the total operational time of electrical equipment. These indicators, designated the "Selachron" range, have been designed in forms suitable for either a.c. or d.c. operation and in sizes suitable for use with voltages between 6 and 300 V, thereby obviating the need for extra switches or relays, and permitting them to be wired to the terminals of the equipment to be timed.

The indicators, which are 1 in. in diameter by $2\frac{3}{8}$ in. in length and weigh less than 2 oz, have no moving parts

Beaver pre-loaded ball screws, up to 95% efficient, operate at -52°C to over 400°C with no backlash...



... ANOTHER ENGINEERING ADVANCE FROM **BRISTOL SIDDELEY**

Bristol Siddeley Engines Limited produce Beaver* pre-loaded ball screws. These ball screws achieve a minimum efficiency of 90% and they can operate within a temperature range of –52° C to 400° C without lubrication, and up to 170° C when lubricated.

Machined and ground to the highest standards of precision engineering Beaver pre-loaded ball screws greatly increase transmission efficiency. They reduce the power required for actuation by as much as 80%, when converting rotary drive into linear output or force input into torque output. By eliminating backlash, with pre-loading, they give precise control over very small increments of motion and a high response frequency. And when compared to conventional screw mechanisms, they provide a predictable operating life which is much longer, require much less maintenance and give more trouble-free operation.

Basic design application analysis

Bristol Siddeley engineers make an exhaustive analysis of each specification. And each unit is specially designed for its particular application. Beaver ball screws are made automatically reversible or with controlled "no-back," with multiple or single circuits. Beaver pre-loaded ball screws have been proved as the most efficient method of converting rotary into linear thrust in over 2,700 engineering applications in many branches of industry. They have been designed already with rated operating load capacities of 370,000 lb (825,000 lb maximum static load) but the maximum potential operating load is, in most cases, limited only by the requirement.

Bristol Siddeley Beaver ball splines have been developed to eliminate the disadvantages of conventional splines. The designs are very effective in minimising friction, particularly when high torsional and bending loads are imposed during linear movement.

**Complete technical and manufacturing co-operation with Beaver Precision Products Inc, Detroit.*

For further information please write to:
J. B. STARKY, SALES MANAGER (BEAVER PRODUCTS DIVISION), BRISTOL SIDDELEY ENGINES LIMITED
PO BOX 17, COVENTRY, ENGLAND

BRISTOL SIDDELEY ENGINES LIMITED

and consist of transparent cartridges containing small, replaceable electro-chemical cells embodying an anode, cathode, and electrolyte. The anode is consumed as current passes through the cell, its length diminishing in proportion to the accumulated hours of operations, as shown by a calibrated scale alongside the anode.

Torque-Controlled Pneumatic Impact Wrench

A new torque-controlled, reversible pneumatic impact wrench, designed for close control of final bolt tightness, has been introduced by the Consolidated Pneumatic Tool Co. Ltd., of London, S.W.6. The new wrench operates as a conventional wrench until the preset torque value is reached, when the torque-control device cuts off the air supply to the motor and the wrench ceases to impact. The required loading is obtained by operation of a torque-adjustment screw located on the handle of the wrench, and a lock-out button on either side can be pressed to lock out the control and allow the wrench to develop its full capacity.

The wrench is available in two forms, i.e., model CP.610–RLTP wrench, which is equipped for a spline drive, and model CP.610–RTP, which has a 1-in. square drive of conventional type. A particular feature of the spline-drive shanks and sockets is the achievement of maximum safety through positive retention of the socket, since the retainer is integral with the shank and is automatic in operation, a quick-release button in the shank freeing the socket for removal. The higher efficiency of the spline connection, as compared with the square drive, also reduces power losses and permits socket changes to be made with greater speed, as well as resulting in more even stress loading of the socket and enabling it to be considerably lighter than the equivalent square-drive socket.

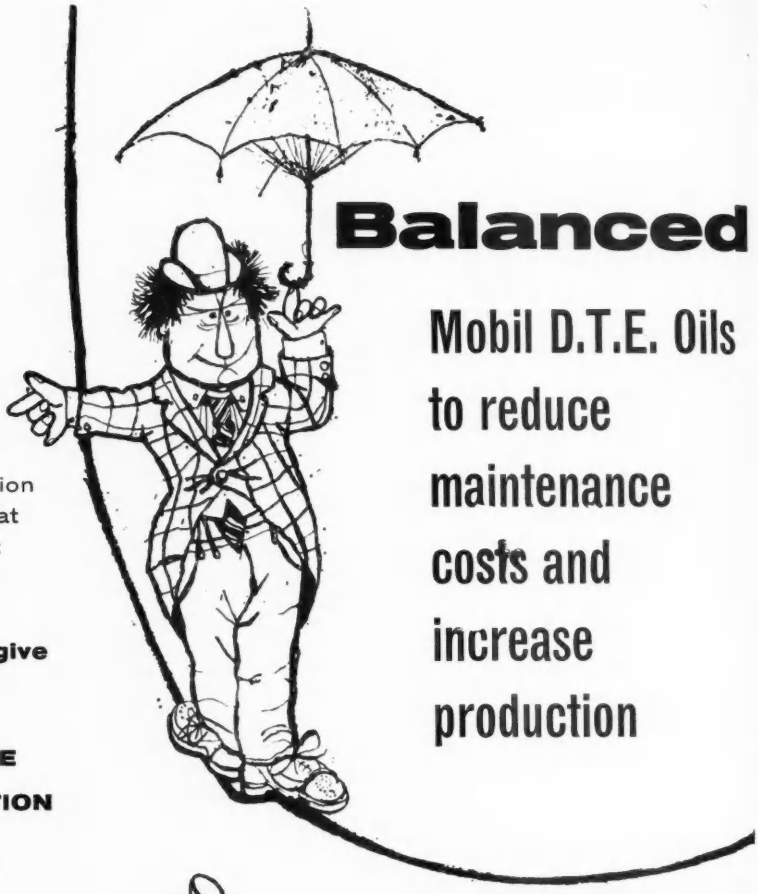
The weight of each model is 23 lb and the overall length 16⅜ in. The maximum bolt size, when using the lock-out, is 1¼ in., and the minimum torque is 300 lb-ft and the maximum 600 lb-ft. When bolting resilient materials, the minimum value of torque can be considerably lowered, while the maximum can be raised when bolting rigid materials.

Portable Hardness Tester for Soft Materials

Designed for use on fabricated parts and assemblies, as well as on raw stock, the "Impressor" hardness tester, manufactured by the Barber-Colman Company, of Rockford, Ill., and distributed in the U.K. by the Industrial Instrument Services Co., of Lozells, Birmingham 19, is a compact portable instrument, weighing only 12 oz, for use on the softer metals and their alloys, and also on other materials, including plastics.

Of simple but robust construction, and neatly shaped to fit the hand comfortably, the patented design of the "Impressor" is such that operating experience is not essential, all that is necessary being to exert a light pressure against the instrument to drive a spring-loaded indenter into the material under test, with the indenter perpendicular to the surface. The instrument can be used in any position and in any space that is sufficient to allow for accommodation of the operator's hand. The hardness reading is instantly indicated on an easily read dial, which is conveniently divided into 100 graduations, no waiting, preloading, or separate measurements being required. The indenter is of hardened steel, precision-ground to ensure uniformity of readings.

The "Impressor", which is supplied complete in a carrying case, with an adjusting wrench and two spare indenters, is available in three models, i.e., Model GYZJ 936 for extremely soft materials, such as lead, linoleum, and leather; Model GYZJ 935 for the very soft metals and the softer plastics; and Model GYZJ 934-1 for soft metals, such as aluminium and its alloys, brass, and copper, and some of the harder plastics, with an approximate Brinell-hardness range of 25 to 150 (10-mm ball and 500-kg load).



Balanced

Mobil D.T.E. Oils to reduce maintenance costs and increase production

Mobil D.T.E. Oils stand head and shoulders above all ordinary oils. They give *balanced* protection and performance that no oil on the market today can equal.

Mobil D.T.E. Oils give you the following advantages:

LONGER OIL LIFE

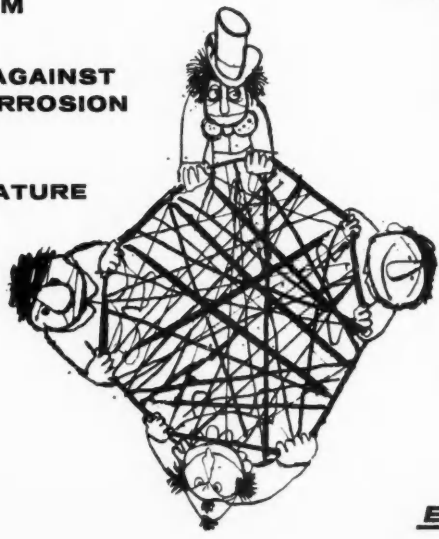
QUICK SEPARATION FROM WATER

FREEDOM FROM DEPOSITS

PROTECTION AGAINST RUST AND CORROSION

LESS WEAR

HIGH TEMPERATURE STABILITY



ASK THE MAN FROM MOBIL ABOUT BALANCED OILS

Our representative will give you the facts — the facts about the performance of Mobil D.T.E. Oils in comparison tests with other well-known hydraulic and circulating oils. Ask the man from Mobil to call and explain how Mobil D.T.E. Oils can reduce maintenance costs and increase production

Mobil

ECONOMY SERVICE

ADDITIONAL ABSTRACTS

The Structure of White Cast Iron

By M. HILLERT and H. STEINHÄUSER

From *Jernkontorets Annaler*, Sweden,
Vol. 144, No. 7, 1960,
pp. 520-559, 51 illustrations.

THE cementite-austenite eutectic, usually called ledeburite, is a well-known constituent of white cast iron, and the purpose of the study of the detailed structure of ledeburite reported in this paper was to find an explanation for the high rate of formation of ledeburite, as compared with graphite eutectic, and also to provide a test of the general validity of the principles governing the decomposition of austenite to various aggregates of ferrite and cementite.

The investigation shows that the structure of the austenite-cementite eutectic is strongly influenced by the tendency of cementite to develop a certain crystallographic plane, the same tendency which causes the formation of pro-eutectic plates of cementite in a hyper-eutectic melt. The tendency of cementite to develop flat faces is so strong that plates may form in a melt, even if austenite is available to allow the formation of a eutectic. The first plate to form gives rise to new plates growing in different directions, a process which is repeated until the whole system contains plates, thus explaining the high rate of formation of white structure as compared with grey structure. The new plates probably form by the outgrowth of fragments broken off from their parent plates.

The formation of a eutectic structure is initiated by austenite growing out over the sides of the plates of cementite as two-dimensional dendrites. Next, the two solid phases, cementite and austenite, grow in a direction perpendicular to the primary plates, first forming an irregular structure, but soon organizing themselves to form a regular, rod-like eutectic.

The solidification process in white cast iron has many characteristic features in common with the transformation of austenite in steel. The theoretical ideas developed in connection with the transformation of austenite also seem to be applicable in the case of white cast iron and may be of quite general applicability.

The tendency of cementite to develop flat faces causes the formation of steps in the solidification front of the regular eutectic. These steps advance edgewise as the regular eutectic grows sideways. An intimate mixture of two kinds of structure will thus form. A great variety of structures results, owing to differences in the distance between the steps and the individual height of the steps, and also to differences in the degree of co-operation between cementite and austenite during edgewise growth. Several characteristic features of the structure of white cast iron are also found in other eutectic systems, where one of the two solid phases has a strong tendency to form flat faces. This factor seems to be of great importance for the development of the structure of eutectics.

A Method of Growing Dislocation-Free Germanium Crystals

By B. OKKERSE

From *Philips Technical Review*, Netherlands,
Vol. 21, No. 11, 1959–60,
pp. 340-345, 7 illustrations.

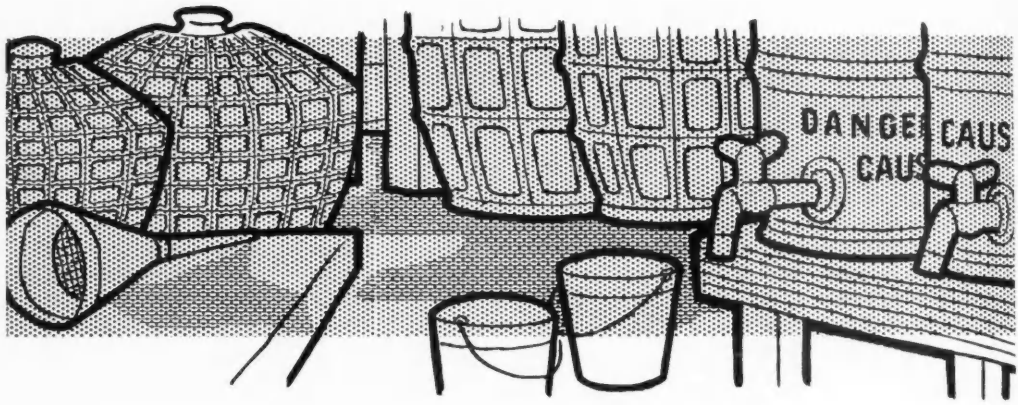
THE presence of dislocations in the lattice of a single crystal may affect the mechanical properties, the diffusion of foreign atoms, the rate of alloying and dissolution, and also, in the case of semiconductors such as silicon and germanium, the life of injected charge carriers. Furthermore, depending on the circumstances, the dislocation may act as a sink or as a source of both vacancies and interstitial atoms, and in this way, too, it may detract from the perfection of the crystal. In many cases, it would therefore be useful to have a material in which one particular type of lattice defect is entirely absent. This requirement, however, can be fulfilled only in respect of one type of defect, i.e., since point defects are thermodynamically stable, only the absence of dislocations enters into consideration.

As described in this article, dislocation-free single crystals of germanium can be produced by a special method of crystal-pulling. The pulling equipment can either be used with an ordinary crucible or with the recently developed floating crucible. After the rotating seed crystal has been brought into contact with the liquid germanium and the pulling process started, the diameter of the growing crystal is gradually reduced to 1 or 2 mm, this being effected by gradually raising the temperature of the melt a few degrees. The new situation is then maintained over a length of growth of about 20 mm. Finally, in a similar way, the diameter is again gradually increased to the required value, and the pulling operation is continued until the crystal is the right length. The pulling rate chosen is less than about 1 mm/min, compared with 2 or 3 mm/min in normal crystal-pulling. The flow rate of the inert gas circulating around the crystal must be kept carefully constant.

The success of this method is based on the fact that, in the thin neck of the crystal produced in this way, the dislocations present tend to intersect the surface and finally "grow out" of the crystal, while the thermal stresses involved are too small to generate fresh dislocations. In the subsequent part of the pulling operation, when the crystal diameter is increased, it is true that the thermal stresses also increase, but no dislocations are created, because of the absence of sources. It is for this reason that it is important to ensure that there are no particles of solid matter, e.g., germanium oxide or graphite from the crucible, floating on the surface of the molten germanium. It should be noted that, although the crystals produced in this way are free from dislocations, they still contain point defects.

SPLASH AND SPRINKLE –

DRIP AND SPILL



Concrete can't take it half so well as . . .

Chemical resistant. Non-slip (whether dry or wet surface). Jointless. Obviates dust hazards. Light in weight. Can be applied to various surfaces. High impact strength.

WITHSTANDS HEAVIEST TRAFFIC

Ceradek will provide the most likely solution to your flooring problems. Our technical staff will gladly advise you on all aspects of Ceradek installation, supplying further details and quotations, as required.

Epoxy
SCREEDED FLOORING

Ceradek

Laid only by :
TECHNICAL APPLICATIONS LTD.
VALLEY WORKS, MONTON ROAD,
ECCLES, LANCASHIRE. **Eccles 1737**

Elimination of Vibration in Vertical Boring and Turning Machines with Long Tool Travels

By V. I. KOPITZYN

From *Vestnik Mashinostroyeniya*, Russia, No. 6, June 1960, pp. 36–37, 3 illustrations.

THE influence of vibrations on the dynamic stability of machine tools has been the subject of many investigations, especially with regard to the deleterious effect of self-excited periodic or fluctuating forces on the useful life of machines, on the efficiency of machining operations, and on tool wear. In machining processes with comparatively long tool travels, such as in the case of deep boring, the internal resonance of the transverse and torsional vibrations causes dynamic instability of the system and sets the tool vibrating if the tool travel is greater than 4·5 to 5 times the diameter of the toolholder.

As described in this article, the dynamic rigidity of vertical boring and turning machines can be increased by providing an additional support to the tool-head of the vertical ram by means of the head of the side ram of the machine. The link between the two tool-heads is achieved by a wedge-shaped component which is fixed into the vertical head and pressed by a short bar, clamped in the side head in a radial direction to increase the stability of the system and to reduce the twist of the vertical ram. It is stated that, by the provision of this additional support, cuts of more uniform thickness are obtained, thereby eliminating one of the most important causes of self-excited vibrations.

It is also claimed that, with this set-up, which has been successfully employed for machining the cylinders of large hydraulic presses and similar heavy components, it has been possible to employ tool travels nine times greater than the maximum diameter of the tool-carrying ram, without any change in the normal operating parameters. Another method of providing additional rigidity to vertical boring and turning machines is achieved by fitting a support to the side ram by means of the vertical ram, either by pressing the vertical head directly against the side ram, or (where the configuration of the component does not make this solution possible) by connecting the two rams by means of a collar fixed around the side ram and hinged to the vertical ram. Furthermore, when machining large-diameter bores which can accommodate two vertical rams, the working ram can be linked by means of a collar and coupling to the head of the other ram. In this case, the danger of resonance is reduced on account of the different lengths and vibration frequencies of the rams under operating conditions.

Some Factors Affecting the Weldability of Cupro-Nickel Alloys

By C. E. WITHERELL,

From *Welding Journal*, U.S.A., Vol. 39, No. 9, September 1960, pp. 411s-416s, 6 illustrations.

WHILE it is true that cupro-nickel alloys are well known for their resistance to corrosion, erosion, and the destructive effects of sea-water, they have, like most other commonly welded materials, not been immune to various welding problems which occur from time to time. Limited work carried out some time ago on the weldability of 70-30 cupro-nickel has shown that welds made on plate having a high content of phosphorus are susceptible to fusion-line cracking. Since then, there have been other instances where fusion-line cracking has been traceable to the presence of phosphorus and possibly also the presence of other elements, such as lead, bismuth, and sulphur. In no case, however, has there been conclusive evidence that fusion-line cracking is the result of high-phosphorus content alone. This paper, therefore, is the result of an investigation to determine the reason for fusion-line cracking—the source of most of the welding difficulties encountered with cupro-nickel alloys.

This investigation, which involved the preparation of nearly 250 compositions of cupro-nickel and close to 500 welds, shows that fusion-line cracking in cupro-nickel welds is primarily the result of low-melting-point segregates that form at the weld interface when certain trace elements or impurities are present in the base metal in sufficient quantities. The cracking seems to occur when the stresses generated by the cooling mass of weld metal exceed the strength of the low-melting-point segregates. Trace elements which have low solid solubility in copper or which form low-melting-point eutectics with copper are chiefly responsible. It should also be noted that the use of nickel or a high-nickel-copper filler, or welding conditions promoting fast cooling rates and rapid solidification of the deposited weld metal, tend to favour the segregation of low-melting-point constituents and thereby increase the likelihood of fusion-line cracking.

Influence Coefficients and Pressure-Vessel Analysis

By G. D. GALLETLY

From *Trans. ASME, J. of Engineering for Industry*, U.S.A., Vol. 82, Series *B*, No. 3, August 1960, pp. 259–269, 8 illustrations.

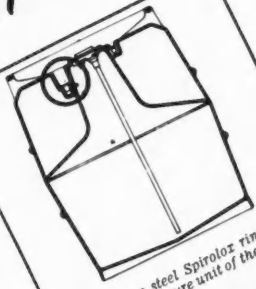
PRESSURE vessels to-day are usually designed in accordance with the provisions of the A.S.M.E. Code for Unfired Pressure Vessels and, insofar as pressure loadings are concerned, the code usually attempts to predict only the direct (i.e., membrane) stresses. The code, of course, recognizes the fact that bending stresses may exist in vessels designed in accordance with its rules. However, design rules for details have usually been framed to hold such stresses at a safe level consistent with experience. The situation with regard to torispherical and ellipsoidal shells appears to be somewhat different. The formulæ for these shells, which are based on tests of heads of various geometries, include both bending and direct

SPIROLOX

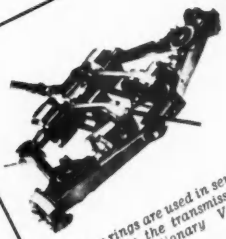
THE RETAINING RING THAT REALLY LOCKS

A size for every purpose!

A Spirolox ring is fitted to the back of the outer cover of the Wilmot Breeden 'Zerotorque' car door lock—used on the B.M.C. Farina range of cars.



A Stainless steel Spirolox ring is applied to the closure unit of the Alumasc metal beer barrel.



Spirolox rings are used in several locations within the transmission system of the revolutionary Van Doorne D.A.F. 600 car.

Spirolox retaining rings are made from two or more concentric turns of high grade flat spring steel. Spirolox have great strength, they can be assembled without the use of special tools, and do not tangle in storage.
Spirolox rings come in a large variety of sizes to suit every application. And Spirolox rings *really* lock.

Write now for full details and samples to Dept. ED11

WELLWORTHY LTD · LYMINGTON · HANTS

WELLWORTHY
'THE CHOICE OF THE EXPERT'

Manufactured under licence from the Ramsey Corporation, U.S.A.

stresses. However, the accuracy of these formulæ, outside the ranges of the tests on which they were based, has not been confirmed.

The reason for not computing the bending stresses in shells is, of course, due to the complex calculations and length of time involved. However, if optimum use of material is desired, plus a realistic knowledge of the elastic stresses in the vessel, then the bending stresses must be calculated. A means is thus required to enable a designer to calculate them quickly and accurately. One such method is that of using tables of influence coefficients, i.e., the stress or deformation at a point in the shell due to unit values of the edge bending loads or unit values of the pressure. These coefficients have been obtained recently for a number of shells of practical interest, and it is the purpose of this paper to show how they should be used.

In addition to describing the utility of influence coefficients for analysing pressure vessels, two relatively complex problems have been selected and their final stress distributions calculated to illustrate the advantages of influence coefficients. These problems deal with (1) a cylinder closed by a torispherical head, and (2) a cylinder joined to a smaller cylinder by an ellipsoidal-toroidal shell. It is shown that accurate stress distributions can be obtained quickly and that a specialized knowledge of shell theory is not required. The method also shows the distribution of bending stresses throughout the shells. These stresses, which can be important, are usually ignored by the various codes.

The Effect of Tighter Conductor Tension on Transmission-Line Costs

By E. FRITZ

From *Power Apparatus and Systems* (*A.I.E.E.*), U.S.A.,
No. 49, August 1960,
pp. 513-529, 9 illustrations.

ALTHOUGH transmission lines mainly have an electrical function to perform, overhead conductors have both an electrical and a structural duty. In fact, conductor tension plays an important part in the capital cost of transmission lines, and it is the object of this paper to demonstrate to what degree the weight of the supporting structures, the steel-core/aluminium ratio, and the selection of optimum conductivity are influenced by loose or tight conductor stringing, and also to show what savings could be effected if tighter conductor tensions were employed. In addition, consideration is given to the precautions that must be taken if tighter tensions are used, particularly with regard to maximum design tensions, the effects of creep, and fatigue limitations.

The conclusions derived from this paper may be summarized as follows:—

(1) The cost estimates and comparisons in this paper sustain the hypothesis that tighter conductor stringing can result in substantial savings in the first cost of overhead transmission lines.

(2) The annual cost of energy losses can be reduced by substituting lighter-cored cables at tighter tensions for loosely strung larger-cored cables of smaller conductivity at no increase in first cost.

(3) The treatment of the broken-wire load is the greatest single obstacle in cost reduction with increased conductor tension. The influence which the treatment of the longitudinal load has on tower weights indicates that consideration of conductor tension becomes an even more important cost factor as the broken-wire loads are relaxed.

(4) It is emphasised that tighter conductor tensions will require a judicious selection of vibration-protection hardware at suspension and strain points; otherwise, fatigue breaks in the cable elements may well occur.

Selective Removal of Chromium from Stainless Steel by Air-Contaminated Lithium

By R. E. SEEBOLD, L. S. BIRKS, and E. J. BROOKS

From *Corrosion*, U.S.A.,
Vol. 16, No. 9, September 1960,
pp. 140-142, 3 illustrations.

WHEN liquid metals are used as heat-exchange media, the major problem, particularly for temperatures near 1500°F, has been that of finding a suitable container material, which should, ideally, be inert to the liquid metal. Although no such materials have actually been found in practice, various types of steels have been suggested and used, purely on the basis of their commercial availability.

This paper reports the results of an investigation into the corrosive action of high-purity and air-contaminated lithium on Type 304 stainless steel in non-isothermal closed systems in which the maximum and minimum temperatures were 1500°F and 800°F respectively. The results showed that, when high-purity lithium was contained under a helium atmosphere, only a slight mass-transfer action took place after 720 hr at 1500°F. When, however, high-purity lithium was contaminated with 0·36% air, the mass-transfer deposit after only 72 hr at 1500°F was pronounced, chemical analysis revealing a concentration of 4·6% chromium in the lithium in the immediate vicinity of the mass-transfer deposit, and 16·9% chromium in the cooler portion of the lithium beyond the deposit zone. Experiments carried out with lithium which had been contaminated with air for a long time yielded similar results, differing only in the degree of mass-transfer action.

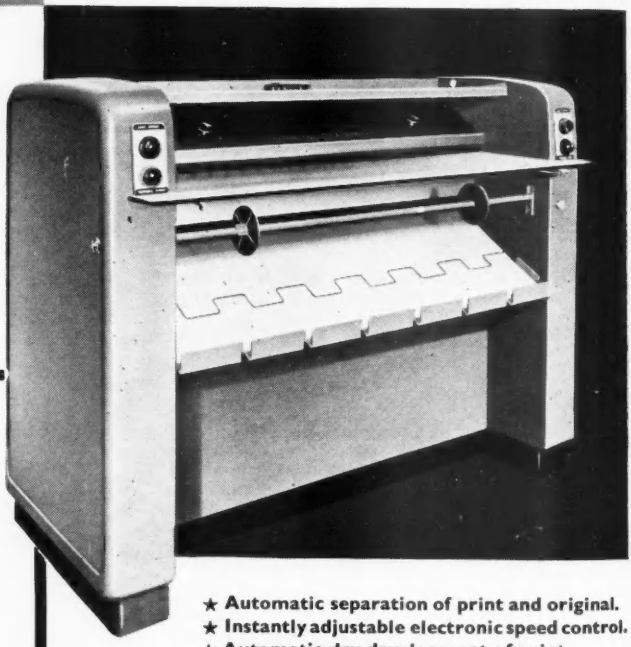
The results of this investigation indicate that chromium is selectively removed to depths of 10 microns from the surface of Type 304 stainless steel by air-contaminated lithium at 1500°F and remains dissolved in the lithium, where it is soluble to the extent of at least 25%. The other steel constituents are mass-transferred in their original relative proportions and are deposited as strongly magnetic dendrites. Deterioration of the stainless steel appears to occur primarily in conjunction with air contamination of the lithium and proceeds through the selective leaching of chromium from the steel.

Steels containing chromium cannot therefore be recommended for use in lithium systems where air contamination is possible.

NOW YOU CAN CHOOSE FROM 3 One Step MACHINES

Only with a machine which offers entirely automatic, reliable separation can you take full advantage of really high speeds. The One-Step is one of the few high-speed copiers which enables any operator to take full advantage of the maximum output.
There are now three models to choose from.

Model 33 — Speeds up to 40 ft. per min.
Model 34 — Speeds up to 50 ft. per min.
Model 36 — Speeds up to 50 ft. per min. with revolutionary Variable Wattage Lamp.



★ **Automatic separation of print and original.**
★ **Instantly adjustable electronic speed control.**
★ **Automatic dry development of print.**
★ **Automatic stacking of print and original.**
★ **Automatic regulation of developer feed.**

OZALID

OZALID COMPANY LTD., Langston Rd., Loughton, Essex. Tel: Loughton 5544.
OZALID (Northern) LTD., 16 McPhater St., Glasgow C. Tel: Douglas 7271

New Materials, Processes, and Equipment

Lightweight Diesel Engine

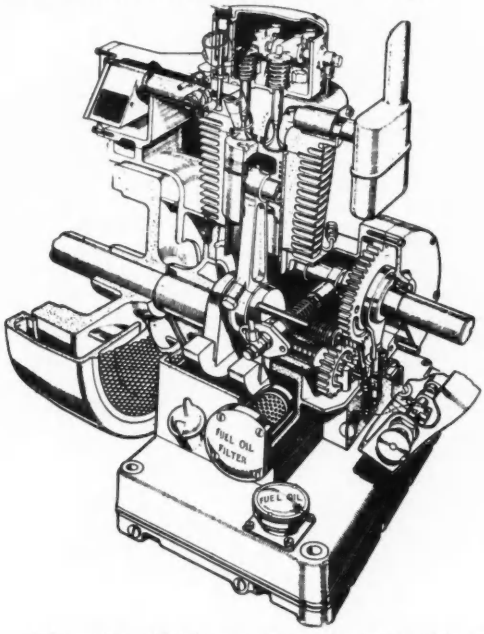
Developing 4 bhp at a shaft speed of 3000 rpm, the new Villiers D.270 diesel engine, announced by The Villiers Engineering Company Limited, of Wolverhampton, embodies a number of special design features, some of them breaking with diesel-engine tradition. Thus, extensive use has been made of aluminium, to the almost total exclusion of iron in the cylinder, cylinder-head, crankcase, flywheel housing, and base-mounting castings. The result is a rustless engine weighing less than 160 lb, i.e., some 75 lb lighter than any other British diesel of comparable capacity and with an outstanding power/weight ratio.

The D.270 is a vertical, four-stroke, single-cylinder engine, with a bore and stroke of 2¾ in. The engine is fully enclosed, cooling air being drawn through a screen behind the flywheel housing into the cooling-air ducting by a centrifugal fan, which is built integrally with the flywheel. Air for combustion within the engine is also drawn from this supply, the fan acting as a centrifugal pre-cleaner before the air passes through an oil-wash cleaner on its way to the combustion chamber. This arrangement not only provides a neater installation, but improves engine efficiency, because the induced air is slightly above atmospheric pressure.

Particular attention has been paid to the rigidity of the crankcase, into which have been built the high-pressure fuel pump, fuel filter, and lubricating-oil filter. A plastic flap-valve type of breather is fitted and maintains a slight depression within the crankcase. Synthetic-rubber seals are fitted to both shaft outlets. The flywheel housing has a machined facing and is sufficiently rigid to allow the close coupling of driven units to this side of the engine, if desired, this arrangement being further simplified by the location of the cooling-air intake at the engine side of the flywheel housing. Incorporated in the crankcase are drilled lubricating-oil passages and a spring-loaded ball relief oil-pressure valve with an inserted phosphor-bronze seat. The lubrication system is operated by a camshaft-driven plunger-type pump which lifts the oil from the base tank, through a steel-gauze filter and a series of ball valves and feeds it under pressure to a full-flow felt-element filter and then to a drilled main gallery for distribution to the various parts of the engine.

In the standard engine, the fuel oil is carried in a base fuel tank of 1 gallon capacity. A low-pressure piston pump, camshaft-driven in the same way as the lubrication system, maintains a low pressure in the fuel-oil supply up to the high-pressure pump. The fuel oil is drawn through a steel-gauze strainer and fed through ball valves to a paper-element filter and up to a gallery surrounding the high-pressure pump. From the operator's point of view, the great advantage of this fuel system, which is novel for small-capacity diesels, is that it is self-venting, and the possibility of an air lock in the fuel line whenever the fuel tank runs dry is thus totally eliminated.

The engine is equipped with a totally enclosed, crankshaft-speed, centrifugal governor, the weights of which are carried on the timing-gear wheel fitted to the crankshaft. Good care has been taken of cold starting, the provision of an oil-injection device in the rocker box ensuring simplified starting at temperatures down to 20°F. In the standard engine, starting is by means of a detachable starting-handle, which is used on the camshaft extension. As the camshaft runs at half the engine speed, this arrangement greatly simplifies starting. If required, a 12-V electric starter and generator are available.



The engine, which incorporates a simple "stop/start" control, will continue to operate efficiently up to a 30-deg. angle of tilt in any direction. An interesting point is that the breather hole has been eliminated from the top and is located on the underside of the filler cap, with the object of preventing fuel contamination under dirty and dusty operating conditions. A sheet-metal silencer, which reduces exhaust noise to an acceptable industrial level, is fitted as standard.

An extensive range of auxiliary equipment to suit the engine for a variety of applications is available. Thus, for certain applications, a single-plate clutch can be fitted in a suitable housing to the flywheel end of the engine. Also, if desired, a tractor-type sump can be fitted in place of the normal base tank. This sump holds lubricating oil only and is used in conjunction with a separate fuel tank. In this form, the weight of the engine is reduced by a further 15 lb, and it becomes more suitable for powering hand tractors and similar types of machines.

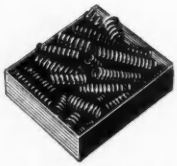
In its standard form, the engine has power-take-off

THAT *Experimental Spring* YOU WANT IS WAITING FOR YOU IN THIS BOX ...

No. 1217. One gross Assorted Springs. A complete Garage Service Kit. 42/- each.

If not, try another box in the Terry Assorted Springs range

No. 1200. Three dozen Assorted Light Expansion Springs, suitable for carburettor control, etc. 13/6.

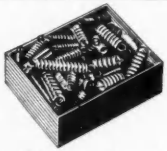


No. 98A. Three dozen Assorted 1" to 4" long, $\frac{1}{2}$" to $\frac{3}{4}$" diam., 19G to 15G. 5/6.

No. 753. Three dozen Assorted Light Expansion $\frac{1}{4}$" to $\frac{1}{2}$" diam., 2" to 6" long, 22 to 18 S.W.G. 10/6.

No. 760. Three dozen Assorted Light Compression Springs. 1" to 4" long, 22 to 18 S.W.G., $\frac{1}{2}$" to $\frac{3}{4}$" diam. 6/6.

No. 757. Extra Light Compression, 1 gross Assorted, $\frac{1}{8}$" to $\frac{1}{16}$" diam., $\frac{1}{2}$" to 2$\frac{1}{2}$" long, 27 to 19 S.W.G. 15/-.



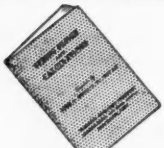
No. 758. Fine Expansion Springs. 1 gross Assorted $\frac{1}{8}$" to $\frac{1}{4}$" diam., $\frac{1}{4}$" to 2" long, 27 to 20 S.W.G. 15/-.

We know *exactly* how difficult it is to find springs for experimental work . . . we've been making quality springs for over 100 years. So, we confidently offer you our excellent range of small boxed assortments which covers a very wide range. We can only show a *few* boxes. Send us a p.c. for our full list. If ever you are stuck with a spring problem let our Research Department put their long experience at your disposal.

Have you a Presswork problem?

If so, the help of our Design Staff is yours for the asking.

TERRY'S *for SPRINGS*



Really interested in Springs? "Spring Design and Calculations" 9th Edition tells all — post free 12/6.

Cut Production Costs with Terry's Wire CIRCLIPS. We can supply immediately from stock — from $\frac{1}{4}$" to $\frac{5}{8}$".

Looking for good Hose Clips? Send for a Sample of Terry's Security Worm Drive Hose Clip and price list.

HERBERT TERRY & SONS LTD

Redditch, Worcs.

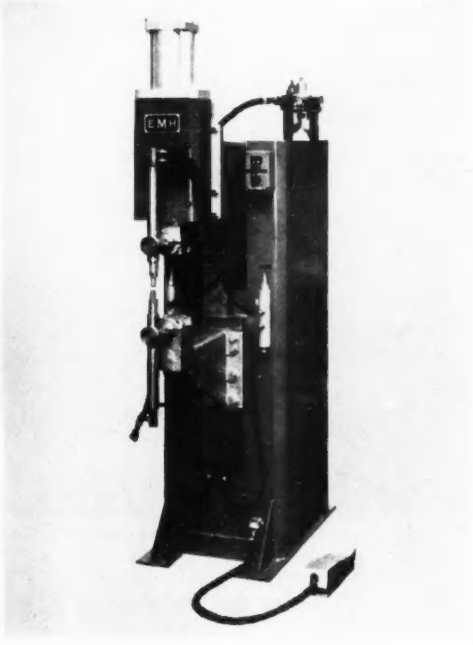
(Makers of Quality Springs, Wireforms and Presswork for over 100 years) HT30C

points at the crankshaft at engine speed and at the camshaft at half engine speed, rotation being clockwise, looking on the shaft ends. The flywheel-end drive can be adapted to take 3 : 1 and 6½ : 1 reduction gears, which can be supplied with or without an industrial clutch. In addition, for controlling both the idling and maximum speeds of the engine, a variable-speed governor can be fitted. The control can either be mounted directly on the engine or arranged for remote control by means of a Bowden-type cable. Between the idling and maximum speeds the fuel input is under direct control.

Another auxiliary is a spent cooling-air adaptor, which can replace the standard casing, to enable the cooling air to be ducted well away from the engine. The exhaust pipe can also be taken out co-axially with this ducting, this being particularly valuable in marine auxiliary installations or wherever the engine is installed in confined spaces. Where the drive is taken from the camshaft, auxiliary equipment is available to enable the engine to be cranked from the flywheel end of the crankshaft.

High-Speed Medium-Duty Spot-Welder

The Type M.50 Mk. III medium-duty spot-welder, recently introduced by Electro Mechan-Heat Limited, of Kingston-upon-Thames, Surrey, has a nominal rating of 50 kVA at a 50% duty cycle and has been designed primarily for use with bright mild-steel sheet of from 18 to 22 gauge. Producing up to 300 spot-welds per minute, the machine is suitable for stitch-welding. A special feature is the welding head, which has a very low coefficient of friction, being fitted with hardened-steel rollers mounted on ball bearings and machined at the periphery to a Vee-shaped profile, which engages the knife-edge of a hardened steel guide, so that contact is made over a very small working surface and easy movement of the ram is ensured.



Welding pressure at the electrode tips is of the order of 1100 psi at an air-line pressure of 80 psi, this being achieved by mounting a standard air cylinder of 5 in. diameter on the welding head. An air reservoir is incorporated to reduce the effect of pressure irregularities from small-bore feed pipes when working at high welding speeds. An air-pressure regulator is also provided. The electrode clamps fitted to the upper and lower arms are movable and can be turned horizontally through 180 deg. to facilitate the spot-welding of long sections. The electrode holders can be adjusted vertically in the clamps, and the lower arm can be raised or lowered through 8 in. of movement. The machine is equipped with a standard Electro Mechan-Heat stacked-core transformer, heat regulation being obtained through an 8-position tap link panel.

As an optional extra, a special "high-lift" air cylinder can be fitted, allowing the electrode tips to be opened to a maximum of 5 in. for the insertion or removal of work-pieces and then returned to the normal gap for welding. For machines fitted with this air cylinder, two foot pedals are supplied, the first bringing the welding head down to a normal spot-welding position, and the second initiating the welding cycle. The welding cycle is controlled by a 3-stage or 4-stage electronic timer in conjunction with an ignitron contactor. Squeeze, weld, forge, and off time can each be varied between 3 and 70 cycles (based on a 50-cps a.c. supply) by means of stepless controls fitted to each stage of the cycle.

Tropicalized Miniature Shaded-Pole Motors

Fully tropicalized to operate under virtually any weather conditions, and specially designed to meet the requirements of Ministry of Aviation Specification DTD 1085/B, a new low-cost miniature shaded-pole motor, announced by B.V.C. Electronic Developments, Ltd., of Leatherhead, Surrey, has been produced to a much higher precision than is normally associated with equipment of this type. As such, it can meet many requirements for which more expensive types are usually employed, typical applications including its use in fans and actuators, in drives for mixers in corrosive atmospheres, in cooling apparatus for television cameras, and in several types of electronic computers.

The motor is continuously rated (without air-stream cooling) at 12 W, with a 2-W output, and operates on mains voltages of 230/115 V up to a maximum speed of 2700 rpm. A 50-W version, with an output of 12 W, is also available for use where a higher power is required.

Transistorized Control Equipment for Lifts

Believed to be the first application of the use of transistors throughout for the control of lift operation, the new electronic equipment developed by J. & E. Hall Ltd., of Dartford, possesses a number of outstanding advantages over conventional control equipment for lifts. Thus, for instance, with mechanical selectors, there is little choice regarding their position, whereas the new control unit is small and light and is easy to install, and its position in relation to the remainder of the installation is not dictated by any mechanical requirements, so that it can be sited in the best position for ease of installation and accessibility. Some idea of the greatly reduced size of this type of unit can be gathered from the fact that a

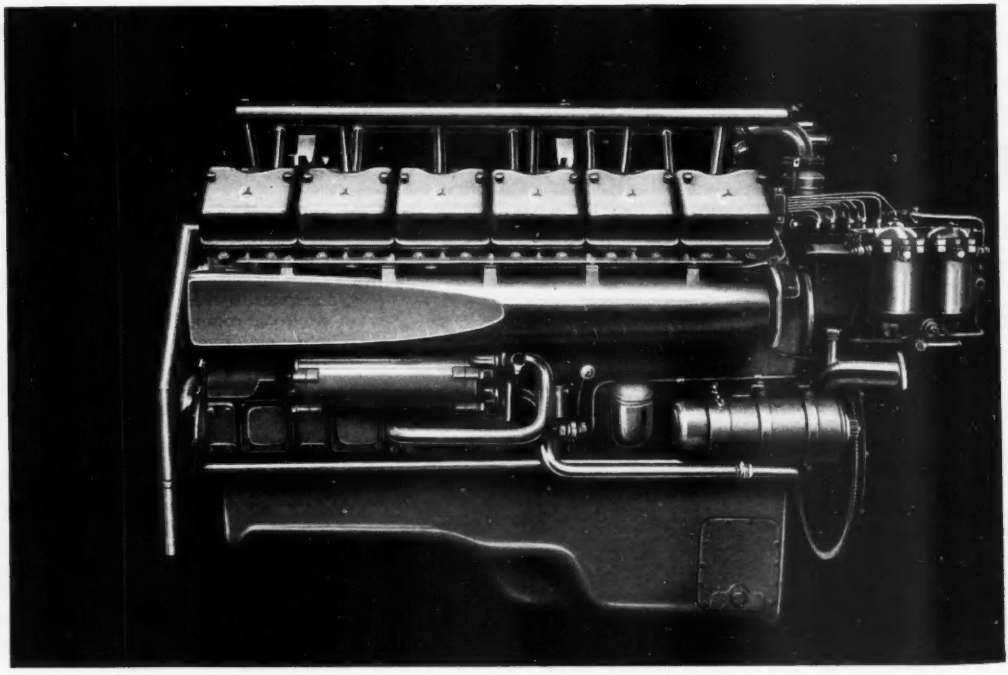
Engines perfect for the railways

Rail vehicles with Mercedes-Benz Diesel engines are in service all over the world and experience in practice has shown that the Mercedes-Benz high speed Diesel is particulary well suited as power unit for locomotives.

There are good reasons for this: The Mercedes-Benz high speed Diesels are light and need little space – characteristics required by the railway engineer. They are of robust construction and capable of withstanding high loads; that is why Mercedes-Benz Diesels are dependable – and the railway time table demands reliable engines. Furthermore Mercedes-Benz Diesels are economical: They use little fuel, and they are easy to service.

For every purpose in rail transport there is a suitable engine in the range produced by Daimler-Benz: – for express trains locomotives and rail cars, for shunting and heavy haulage locomotives.

092 MA●



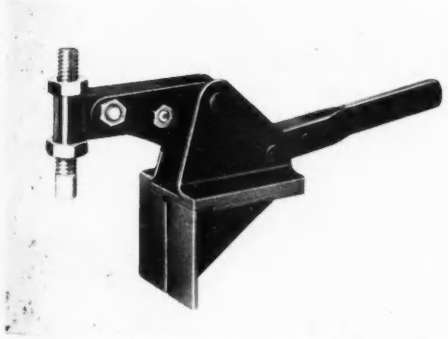
MERCEDES-BENZ DIESEL

transistorized control unit of this type for eight floors measures only $12\frac{1}{2} \times 6 \times 18$ in. high. Furthermore, the static switching unit contains no moving parts at all, its operation being entirely electronic. By eliminating relays, with their numerous contacts, maintenance requirements are virtually eliminated completely and, in this connection, it should be mentioned that the prototype unit, after a year of continuous operation, proved entirely reliable and required no attention or maintenance whatsoever.

The functions of control and selection are combined in a single unit, which is entirely enclosed and dustproof. A control system is built up from assemblies, each of which provides control for one floor, three basic types being used, covering terminal floors, intermediate floors, and output respectively, each with its own selector unit. All assemblies can be quickly removed in the event of a defect, and a spare substituted and connected up immediately, only three small basic transistor units being required for this purpose in installations of any size. In accordance with modern practice, the connections from each assembly are provided with solderless taper-pin terminations, permitting instant connection or disconnection from the terminal blocks on the frame. As the unit operates on a low voltage and very small currents are involved, easily handled light-gauge wiring is used, while "live" wiring presents no danger.

Front-Mounting-Clamps

A new range of front-mounting clamps recently introduced by Speed Tools Ltd., of London, W.1, is stated to possess a number of advantages in certain types of work. Thus, for instance, in assembly work where clamps have to be positioned outside the workpiece, it has been necessary in the past to extend the baseplate of the assembly fixture to accommodate the clamp. The new front-mounting clamps, however, can be fitted to the edges of the fixture baseplate, thereby reducing the size and weight of the complete fixture.

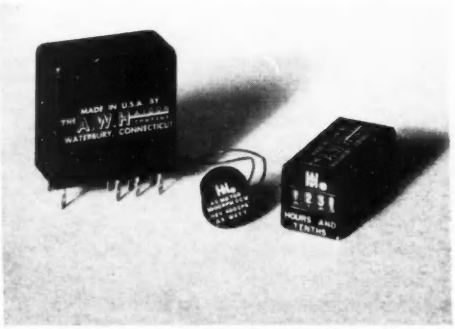


The basic feature of these clamps is that they are equipped with twin flanged gussets welded to the underside of the base, providing a means of mounting in line with the clamping pressure. One of the most useful features of this type of base is that lining up of the mounting face with the direction of clamping pressure makes it possible to perform numerous clamping operations without the need for special fixture design. For example, it is now possible to mount a clamp underneath a workbench or machine table in such a way that a forward clamping pressure is applied along the upper surface of the bench or table. As a result, the clamps are left entirely free of the work area and, in addition, when the clamps are disengaged, the workpieces are free to slide out over the clamps.

At present, these clamps are available in nine models, six of which are vertical types, while three are flat or horizontal designs. A typical flat design is illustrated.

Micro-Miniature Motor and Timing Devices

Measuring only $\frac{3}{8}$ in. in diameter by $\frac{9}{32}$ in. in length, and weighing just over 0·1 oz, a new 115-V, 400-cps, single-phase hysteresis-type motor manufactured by The A. W. Haydon Company, of Waterbury, Conn., has a consumption of less than 0·5 W, and is rated at $1{\cdot}5 \times 10^{-6}$ hp, with a torque of 0·0005 oz-in. Although the motor (shown in the centre of the illustration) is especially useful in instruments and computers, for actuating selector switches, tape handling, and process timing, and other applications where space is limited, it has been specifically developed for powering two micro-miniature timing devices.



One of these devices is a hermetically sealed repeat-cycle timer, measuring $0{\cdot}5 \times 1 \times 1$ in. and weighing 1 oz. In this timer (seen at the left of the illustration), three roller switches are driven at 1 rpm by the motor, the switches being rated at 7 A resistive at 28 V d.c. and 5 A resistive and inductive at 60-cps a.c. 115/230 V. Designed for repeated switch-control functions, where space and weight considerations are of primary importance, and possessing outstanding resistance to severe environmental conditions, the timer can be used in airborne computers to pulse or programme circuits, as well as in any conventional timer applications, e.g., telemetering, circuit programming, or operations utilizing a time base.

The second device is believed to be the smallest elapsed-time indicator ever produced, measuring 0·5 in. square by $1\frac{1}{16}$ in. in length and weighing about 0·75 oz. This four-digit indicator (shown at the right of the illustration) operates on a frequency of 400 cps and is available in two models, one reading tenths of an hour, and the other hours, with respective ranges up to 999·9 and 9999 hr. Both models use drum-type counters with white numerals on a lustreless black background, affording excellent readability, despite their very small size. Although these elapsed-time indicators are intended for use in all situations requiring measurement of running time, it is believed that their main use will be as an integral part of costly electrical or electronic equipment to indicate actual running time.

DOUBLE HERMETAL BOND

REGD. TRADE MARK

epoxy

STRUCTURAL PLASTIC

DISCOVER NEW WAYS of cutting time and cost in making parts and components and for many types of repairs. DOUBLE BOND —an entirely new material—can be used for jointing, filling and moulding, or fabrication of actual parts. This versatile self-setting structural plastic is available in two grades; one moulds like putty for filling in depth, the other spreads like cream for shallower and larger areas. Both set like lead, machine like brass and can be used as a cold solder. Write for 7/6d. trial pack which includes both grades.

contact **Kenilworth**

MAKERS OF 'HERMETITE' JOINTING COMPOUNDS AND SUMMIT ALUMINIUM METALLIC PAINTS

THE KENILWORTH MANUFACTURING CO. LTD., WEST DRAYTON, MIDDLESEX

S.P.I

3 versatile TENITE® plastics

TENITE BUTYRATE
an Eastman plastic

PROPERTIES: Extremely tough, excellent in impact strength, resilient, lightweight, lustrous, weather resistant, dimensionally stable. Available in a wide variety of formulations and an almost unlimited range of transparent, translucent, opaque, metallic and variegated colours plus a crystal-like clear. Adapted to fast injection moulding or continuous extrusion. **TYPICAL USES:** Steering wheels, telephone housings, business machine keys, optical frames, tool handles, football helmets, industrial pipe, skin and blister packaging, outdoor signs.

TENITE ACETATE
an Eastman plastic

PROPERTIES: The original Tenite plastic, offering a wide range of desirable properties including toughness, light weight, impact strength, enduring lustre and low heat conductivity. Available in a variety of formulations and almost unlimited colours. Adapted to fast injection moulding or continuous extrusion. **TYPICAL USES:** Shoe heels, small appliance housings and parts, toothbrush and other tubular containers, toys, novelties, lamp shades, vacuum cleaner parts.

TENITE POLYETHYLENE
an Eastman plastic

PROPERTIES: Flexible or semi-rigid, virtually unbreakable, chemically inert, resistant to water and moisture transmission and to strong acids, excellent electric insulator. Available in natural or wide range of colours and colour concentrates, with or without an antioxidant. Adapted to rapid injection moulding, blow moulding, or continuous extrusion. **TYPICAL USES:** Housewares, toys, bottles, packaging film, pipe and tubing, electric cable wrap and wire coating, coatings for paper, film and foil.

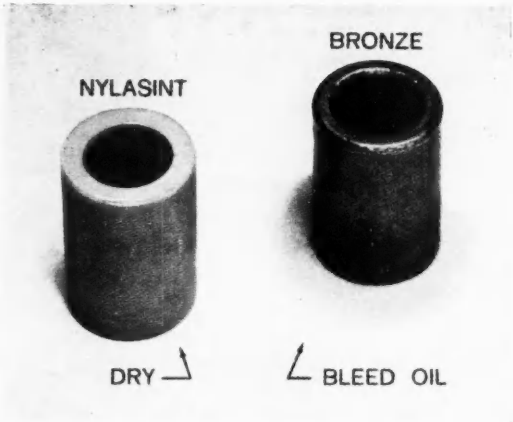
For more information on physical properties and uses, contact

EASTMAN CHEMICAL INTERNATIONAL A. G.
subsidiary of Eastman Kodak Company

Home Office
Baarerstrasse 115, Zug, Switzerland

North European Office
Segbroeklaan 202, The Hague, Netherlands

NYLASINT®. . .
the only nylon with **permanent,** built-in oil lubrication



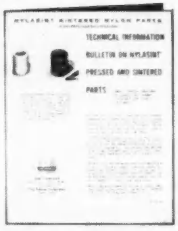
Even through wide temperature ranges and centrifugal speeds up to 1,000 Gs NYLASINT sintered nylon parts won't bleed.

Unlike oil-impregnated, sintered bronze which bleeds readily on paper (see above), NYLASINT holding up to twice as much oil is *permanently* lubricated to reduce friction, increase wear resistance and eliminate contact corrosion.

Inorganic additives also give resilient NYLASINT parts outstanding dimensional stability and high load capacity . . . important for such diverse fields as missile components and steel office furniture.

With NYLASINT you get all the prime advantages of nylon plus *extra* performance no other material offers in applications such as bearings, bushings, guides and washers.

For complete technical data on NYLASINT, write for new NYLASINT Bulletin BR-1111.



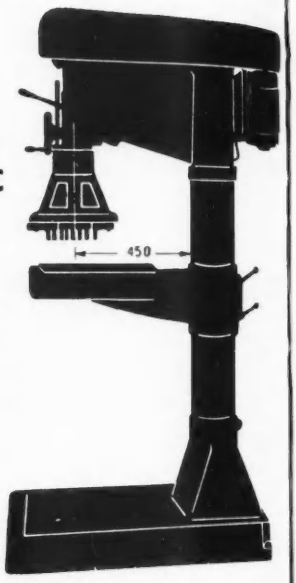
POLYPENCO

INDUSTRIAL PLASTICS

POLYPENCO LIMITED
68-70 Tewin Road, Welwyn Garden City, Herts.
Telephone: Welwyn Garden 5581-3

a subsidiary of The Polymer Corporation Reading, Pa.

COMPLETE RANGE OF BENCH, PILLAR, AND AUTOMATIC DRILLING MACHINES



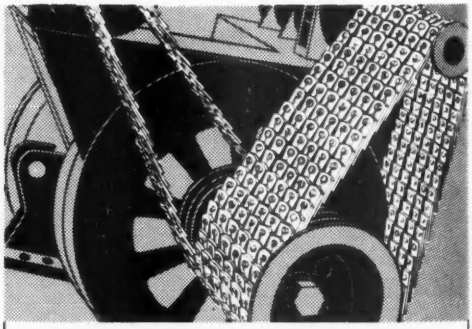
From 6 to 50 mm capacity.

Multiple drilling heads with fixed, variable and in-line arrangement.

SPECIAL MULTIPLE DRILLING HEADS TO CUSTOMERS' DESIGNS.

Agents wanted for unrepresented countries.

Fabbrica Italiana Trapani
IDEAL MILANO-Italy
Piazzale PASOLINI, n.2 - Telef. 694.273



CUT PRODUCTION DELAYS

BRAMMER (REGD)

V LINK BELTING

Fitted on existing V Pulleys in a few minutes without any dismantling. Identical matched sets from stock coil.

H. BRAMMER & CO. LTD.
HUDSON ROAD LEEDS 9.

Arcoy Power Plane. Manufactured by A. Robinson & Company Limited, Bootle. Finished in Luxol Polyurethane Lacquer.

Get sales off to a good start . . .

No range of Industrial Finishes can surpass Luxol; they offer the finest finish for every industrial need. Incorporating all the latest paint developments, Luxol Industrial Finishes provide the eye appeal which influences sales. If your requirements cannot be met from our standard range we will, on request, formulate a special finish for your particular purpose. For *any* information please write to the address below.

with LUXOL Industrial Finishes

Selected finishes in the Luxol range:

LUXOL Standard Stoving Finish
LUXOL Quick Drying Finish
LUXOL Wrinkle Finish
LUXOL Cellulose Finish
LUXOL Hammered Finish
LUXOL Stoving Polychromatic Finish
LUXOL Polyurethanes
EPILUX 2 Stoving Finish

BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH II
MANUFACTURERS OF PAINT
BRITISH PAINTS LIMITED

BRITISH PAINTS LIMITED
Industrial Finishes Division
Portland Road, Newcastle upon Tyne, 2.
Northumberland House. 303-306 High Holborn, London, W.C.1.
31 Wapping, Liverpool.

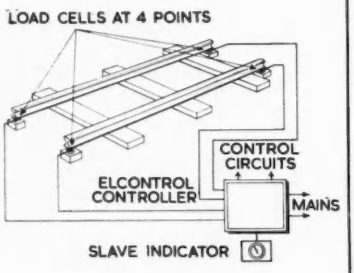
Belfast, Birmingham, Bristol, Cardiff, Glasgow, Leeds, Manchester, Norwich, Plymouth, Sheffield, Southampton, Swansea and all principal towns.

BPL/IF30

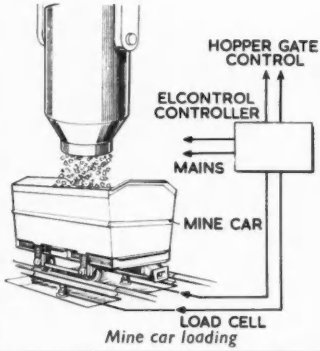
Automatic weight control *by* ELCONTROL

THIS NEW RANGE of electronic weighing equipment is designed for use in almost any industry involving control of plants handling bulk materials such as coal, ores, chemicals, cereals and bulk food stuffs, cement, clay and also finished products.

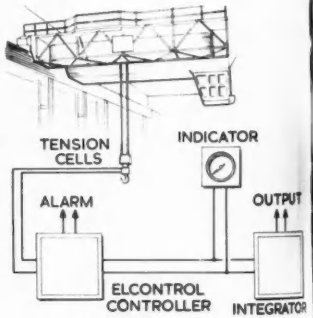
The new Elcontrol type LC4 trip point controller and LC5 trip point controller plus margin indicator have been designed to give reliable control under the most arduous conditions. These are robustly constructed and are very compact. The load cells can be safely used in very wet conditions or even submerged, and flameproof and intrinsically safe equipment can be supplied as standard. The Elcontrol units are primarily controllers, and the control is actuated directly via the amplifier. The control function is therefore not dependent on the operation of a vulnerable instrument system.



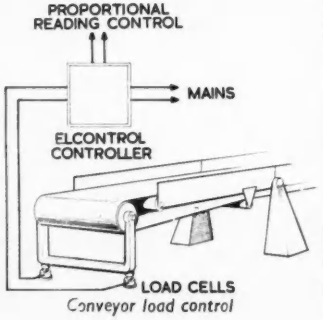
Railway Weighbridge



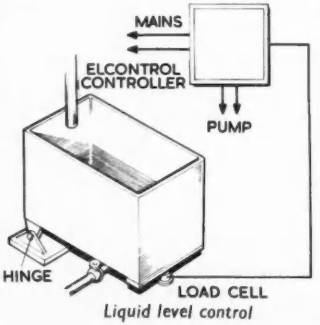
Mine car loading



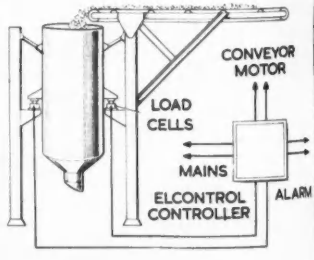
Hoist load limit control



Conveyor load control



Liquid level control



Hopper contents control

An ideal level control

This Elcontrol load cell equipment is of great importance in bulk quantity or level control.

A simple control unit gives an extremely wide differential and can be set up to give high and low level operation over a wide range.

It can also be readily adjusted for operation at varying levels by setting one or two controls.

Our experience of industrial controls is very wide and we welcome enquiries.

LC4/LC5 Control Unit closed.

A typical Elcontrol Load Cell showing separate mounting plate.

Features:

No electrodes or tank fixtures.

Container rests on one or more load cells.

Easy setting at any time.

Weatherproof.

Extremely stable.

Highest reliability.

Close accuracy.

ELCONTROL *Regd. Trade Mark*

electronic control systems

ELCONTROL LTD · HITCHIN · HERTS
Telephone: Hitchin 2411

Appointed Agents	*Telephone*
MIDLANDS: A. M. LOCK & Co. Ltd., Newborough Rd., Solihull	Shirley 5703
N. WEST: A. M. LOCK & Co. Ltd., Union St., Oldham	Main 6744
SCOTLAND: A. R. BOLTON & Co. Ltd., Bankhead Dr., Sighthill, Edinburgh 11	CRA 5235/6

NEW outstanding features!

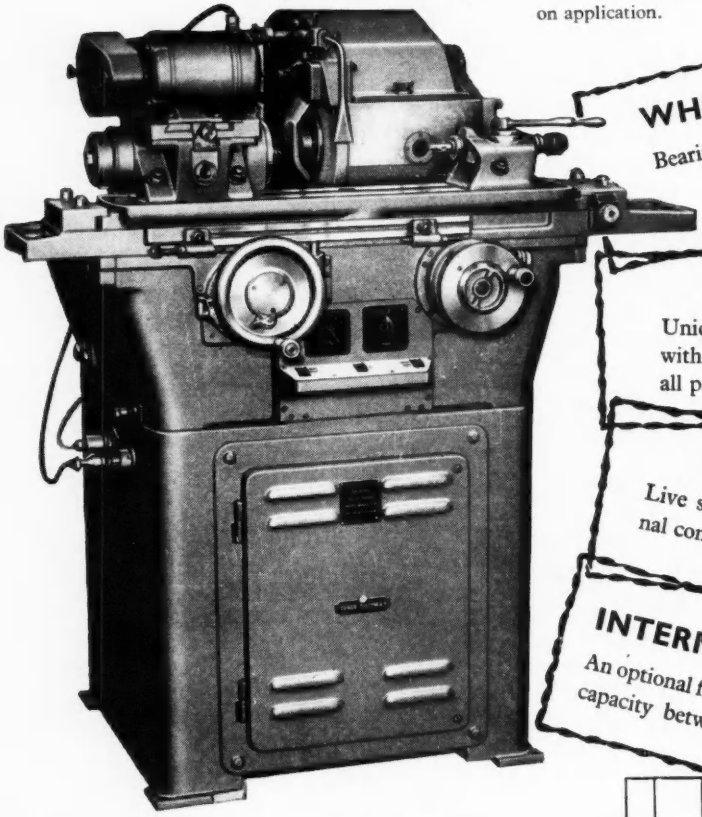
The high accuracy of this 5in. by 12in. Capacity machine lends itself equally for toolrooms or production operations.

JONES — SHIPMAN

on model 1212

5in. × 12in. Capacity

Its new design includes many features for producing the highest precision results in cylindrical grinding, all of which are fully described in Brochure No. 255 on application.



WHEEL-SPINDLE

Bearing pressures temperature controlled according to spindle speeds.

BACKSLIDE

Unique slideway support system with submerged lubrication to all parts.

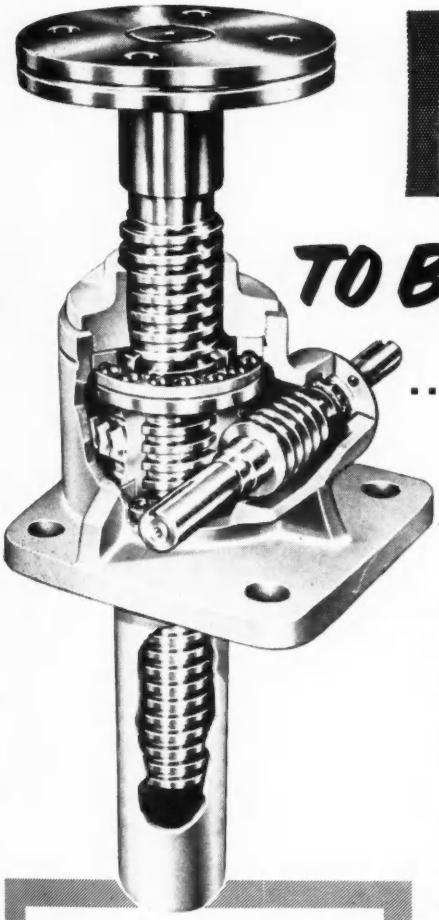
WORKHEAD

Live spindle design with internal cone seating.

INTERNAL GRINDING

An optional feature enabling maximum capacity between chuck and wheel.

A. A. JONES & SHIPMAN LTD.,
LEICESTER
Telephone: 823222
London Office: 50/52 Great Peter Street, London, S.W.1 Tel: Abbey 5908/9



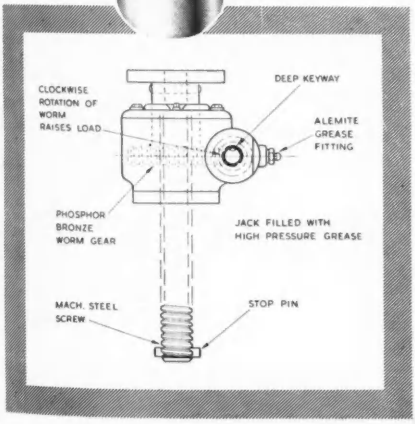
NEW

TO BRITISH INDUSTRY

...a device which every machinery designer should know about

Duff-Norton worm gear jacks provide a purely mechanical means for accurate positioning of loads weighing as much as several hundred tons and maintaining them indefinitely without creep. Operating in any position, and functioning as components of machinery and equipment, they can raise and lower loads, apply pressure or resist impact. Jack capacities range from 5 to 100 tons. When two or more jacks are connected by means of shafting and mitre gear boxes they lift in unison, even when the load is unevenly distributed. They are available with standard raises up to 25 inches, and will provide exactly the same raise for years without adjustment. Worm gear jacks are suitable for operation at ambient temperatures up to 200° F.

Thousands of these jacks are in use in America on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills conveyor lines, arbor presses and numerous other types of equipment. If you have a positioning problem, write for catalogue giving complete information, drawings and full specifications.



Duff-Norton WORM GEAR Jacks

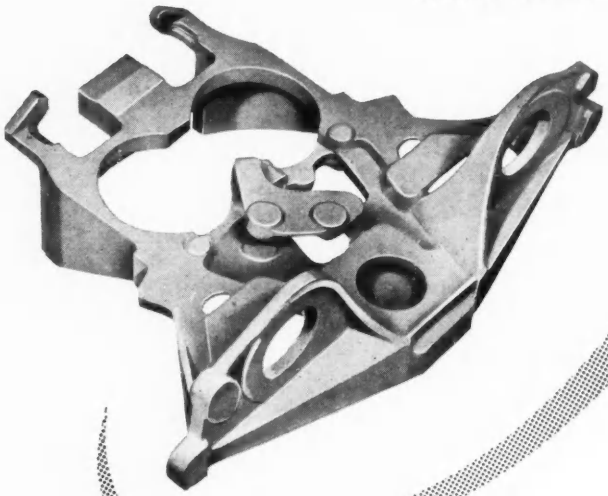
AVAILABLE FROM **Consolidated Pneumatic**

CONSOLIDATED PNEUMATIC TOOL CO. LIMITED · DAWES ROAD · LONDON · S.W.6

CP/233

Cast with Precision

* Aluminium and magnesium alloy castings by sand, die, shell and plaster mould methods.
* Engine blocks and cylinder heads in high duty iron.
* Castings of the highest quality in the desired quantities at the right time.
* The greatest technical experience augmented by quality control of production.



Electronic Equipment Casting in Aluminium produced by Shell Moulding. Wall thickness varies from 0·060″ to 0·100″.

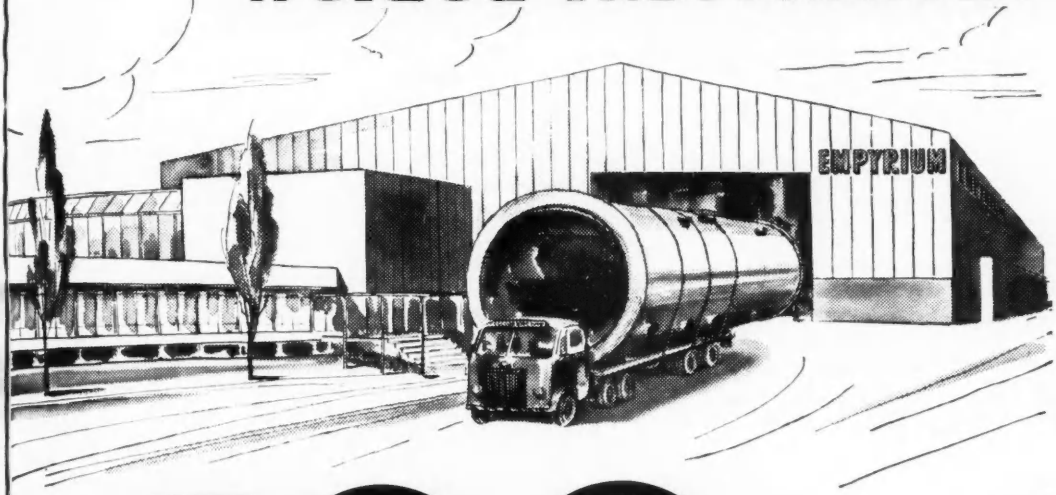
STERLING METALS LTD

PHONE NUNEATON 4221

STERMET

REGD TRADE MARK

EMPYRIUM welded fabrications



UP TO 100 tons

Pressure Vessels. Columns
Heat Exchangers
Press Frames. Transformer and Switchgear Tanks.
Gas Works Plant. Mixers
Machine Tool Frames
Quenching Tanks
Bed Plates. Blast Mains
Evaporators. Separators
Vacuum Vessels. Driers
Air Receivers. Condensers
Storage Tanks. Autoclaves
Crystallizers
Calandrias

What Empyrium Offers You :

Greatly increased and ever-growing capacity for precision fabricating by the most advanced methods, including the automatic submerged arc-welding process.

Welded Fabrication in any size and weight up to 100 tons from our new fabricating and machine shops now in full production.

Full facilities for stress-relieving, galvanising, hydraulic and mechanical testing, X-ray and other non-destructive tests.

The services of creative engineers and skilled designers, who will quickly solve any problem and submit specifications to suit **your** specialised needs.

Fabrications to all specifications, including Lloyd's Register of Shipping, A.S.M.E. Code, and British Standard Specification No. 1500; to all Insurance Company Regulations; and to the exacting requirements of the Petroleum and Oil Companies, and leading Consultative Engineers.

The illustration shows an artist's impression of our New Premises, the manufacturing part of which is now in full production.

For further information write to

EMPYRIUM WELDING & MANUFACTURING CO LTD

Registered Office: Pritchett Street, Birmingham 6, England
Telephone: ASTon Cross 3203/4/5 Telegrams: EMPYRWELD B'HAM.

Works: Moorson Street, and Pritchett Street, Birmingham 6, Old Walsall Road, Great Barr, B'ham 22.

PIONEERS IN WELDING PRACTICE SINCE 1917

W.Ad 4882

NOW THERE ARE EIGHT

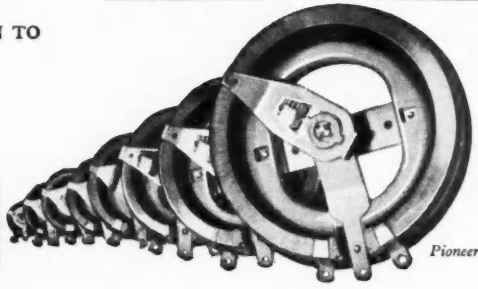
BERCO

TOROIDAL RHEOSTATS

So popular has the original range of five Berco rheostats become that three new models have been introduced. Like all Bercostats they have five important features:—

- VITREOUS ENAMEL BONDED
- HIGHEST MECHANICAL STRENGTH
- MAXIMUM ELECTRICAL PERFORMANCE
- MINIMUM SIZE IN RELATION TO POWER DISSIPATION
- CAN BE USED IN TROPICAL SITUATIONS WITHOUT MODIFICATION

Ohms ± 10%	CURRENT RATINGS							
	L.25	L.50	L.75	L.100	L.150	L.225	L.300	L.500
1	—	7.07	8.66	10.00	12.50	15.0	17.3	22.3
2	3.54	5.00	6.12	7.07	8.66	10.6	12.2	15.8
3	2.89	4.08	5.00	5.75	7.07	8.66	10.0	12.9
5	2.24	3.16	3.88	4.77	5.48	6.71	7.75	10.0
7.5	1.82	2.56	3.16	3.65	4.47	5.48	6.32	8.17
10	1.58	2.24	2.74	3.16	3.88	4.74	5.48	7.07
15	1.29	1.83	2.24	2.58	3.16	3.87	4.47	5.78
25	1.00	1.41	1.73	2.00	2.45	3.00	3.46	4.47
50	.707	1.00	1.23	1.41	1.73	2.12	2.45	3.16
75	.578	.818	1.00	1.15	1.41	1.73	2.00	2.58
100	.500	.707	.866	1.00	1.23	1.50	1.73	2.23
150	.408	.575	.707	.818	1.00	1.22	1.41	1.82
200	.354	.500	.612	.707	.866	1.06	1.22	1.58
350	.268	.378	.463	.535	.655	.803	.926	1.19
500	.224	.316	.388	.447	.548	.671	.775	1.00
1,000	.158	.224	.274	.316	.388	.474	.548	0.708
1,500	.129	.183	.224	.258	.316	.387	.447	.578
2,500	.100	.141	.173	.200	.245	.300	.346	.448
5,000	—	.100	.123	.141	.173	.213	.245	.315
7,500	—	.081	.100	.115	.141	.173	.200	.258
10,000	—	—	—	.110	.125	—	.173	.224
15,000	—	—	—	—	—	—	—	.163



Ask for list 613A, which gives full technical details and prices from :—

THE BRITISH ELECTRIC RESISTANCE CO. LTD.

Queensway, Ponders End, Middlesex.

Phone : Howard 2411
Grams : Vitrohm Enfield

Pioneers of the toriodally wound rheostats in England.

BERCO

BR 1321-BXH

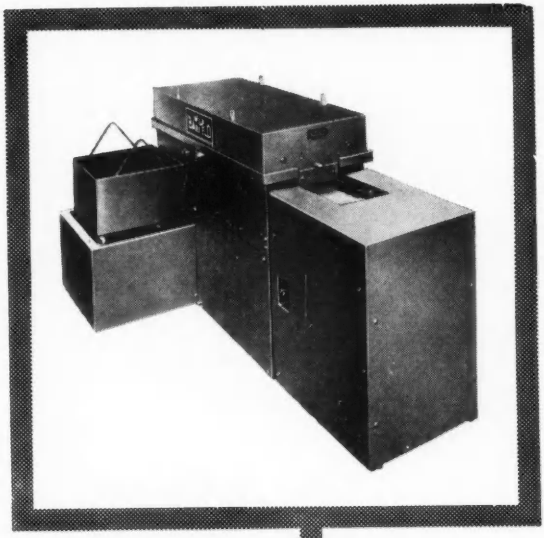
The BIBBY *Resilient* COUPLING

World famous for outstanding performance and reliability. Made in a wide range of types, all employing the same basic principle of Bibby design.

Special types include: Brakewheel, Cardan Shaft, Turbine, Shear pin, Controlled Torque, Spacer and others.

THE WELLMAN BIBBY COMPANY LIMITED, PARNELL HOUSE, WILTON ROAD, LONDON, S.W.1

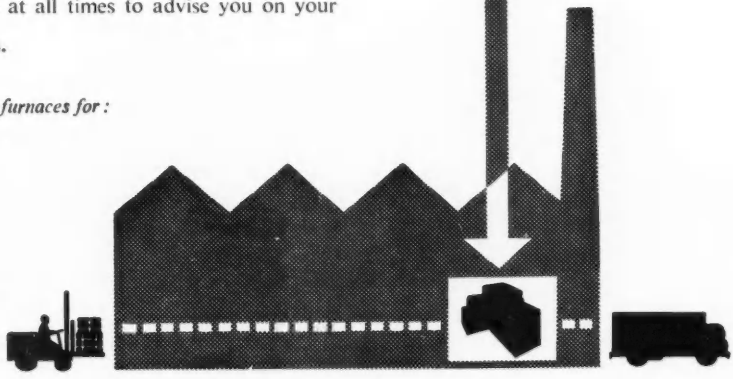
Fit Wild-Barfield furnaces into *your* production line



A Wild-Barfield furnace will bring immediate advantages. It speeds up production and helps to cut costs by eliminating delays and wasteful handling. Built to the highest standards of workmanship, these furnaces offer consistent results and minimum maintenance. The Wild-Barfield Research Department is available at all times to advise you on your heat-treatment problems.

Continuous and batch type furnaces for :

NORMALISING
HARDENING
TEMPERING
GAS CARBURISING
CARBONITRIDING
BRIGHT ANNEALING
etc.



ELECTRIC WILD BARFIELD FURNACES

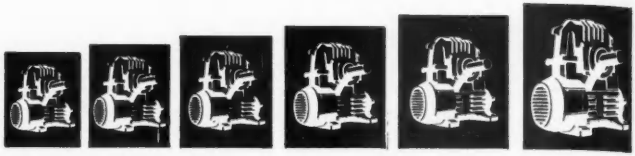
FOR ALL HEAT-TREATMENT PURPOSES

WILD-BARFIELD ELECTRIC FURNACES LIMITED

ELECFURN WORKS, OTTERSPOOL WAY, WATFORD BY-PASS, WATFORD, HERTS.

Telephone: Watford 26091 (8 lines)

W362



AN IMPORTANT ADDITION TO OUR FAMOUS RANGE OF GEAR BOXES

3½"

The new Holroyd 3½" centres Worm Speed Reducer will in future take its place between the present 3" and 4" sizes in our standard range of gear boxes. Its purpose is to fill the rather wide gap in power capacity which previously existed between the 3" and 4" sizes. Thus it will give you more latitude in choice of reducers and greater economy in those many instances where it happens to suit the power requirements of your application. It is built to the same high standards as all the other gear boxes in our range. Please write for details.

Say **Holroyd** first for worm gears and gear units

John Holroyd & Co. Ltd., Milnrow, Lancs.

CRC 815

ACCURATELY MACHINED

QUALITY BRONZE

CASTINGS

Typical Examples of our Production . . . .

★ CENTRIFUGALLY CAST

★ SHELL CAST

OR

★ CONTINUOUSLY CAST

OUR TECHNICAL REPRESENTATIVE WILL BE PLEASED TO DISCUSS THE APPLICATION OF THESE PROCESSES TO YOUR REQUIREMENTS

Holfos Bronze Regd.

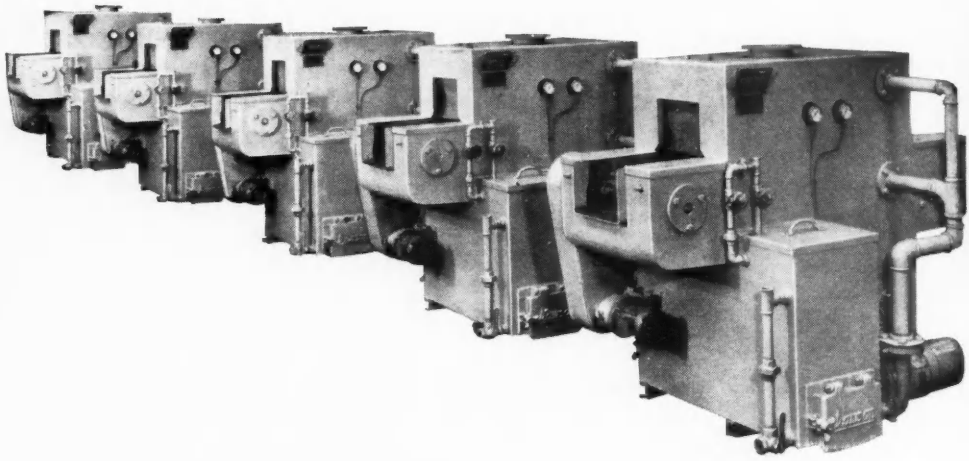
A wide range of engineering components in small and large quantities cast in the HOLFOS foundries in copper-base alloys to standard specifications, precision finished on the most modern machines.

Please write for literature to :—

JOHN HOLROYD & COMPANY LIMITED

P.O. Box 24 · Holfos Works · Rochdale · Lancs · Telephone 3155

Metal Cleaning for Mass Production...



...with Dawson Plant

For all metal cleaning and degreasing, from small and simple things like nuts and bolts to large and intricate subjects like diesel cylinder blocks, there is a Dawson machine to do the job. And do it thoroughly at a speed to suit the production line, and at a cost to make every shareholder clasp his hands with contentment. Whether your factory covers half an acre or 100 acres there is a Dawson machine to suit your needs. Comprehensive catalogue will be sent on request.

Dawson

METAL PRE-TREATMENT PLANT

Sole Distributors
DRUMMOND - ASQUITH LTD.
King Edward House, New St., Birmingham
Tel. Midland 3431

Manufacturers :
DAWSON BROS. LTD., Gomersal, Near Leeds. Tel : Cleckheaton 3422 (7 lines)
LONDON WORKS, 406 Roding Lane South, Woodford Green, Essex. Tel : Crescent 7777 (4 lines).

FELCO
LIFTING APPLIANCES

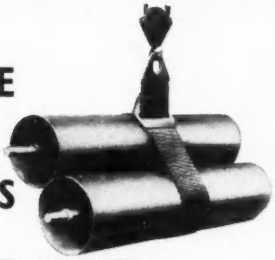
RATCHET HOISTS

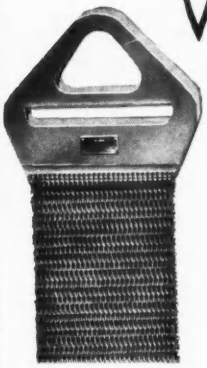
Incorporating a patented Overload Preventer giving greater security and safety to the operator, also reducing wear and saving cost of maintenance. A free-wheeling feature enables quick adjustment of unloaded chains.

Sole Distributors For

Wedco

WIRE BELT SLINGS





THE SLING WITH 1,000 USES

The "Wedco" Wire Belt Sling has the strength of steel combined with maximum flexibility and a wide bearing surface giving exceptional load stability.
Made from thousands of strands of sturdy woven wire in a smooth transverse loop construction "Wedco" Wire Belt Slings cannot snap or tear. They are safer, easier to handle, faster to rig and will not whip, kink or tangle.
In the field of mechanical handling this is something you should know more about, write us for the fullest details.

TRIPLE GEAR CHAIN BLOCKS

Short headroom. Lightweight. Compact for high efficiency. Capacities from 4 tons to 10 tons.

LOW-LIFT JACKS

Large capacity for use in confined spaces. Light enough for ONE MAN to use. Swaying under load eliminated by large diameter cylinder providing easy adjustment of height. Capacities from 10 to 30 tons.

"ADJUST-A-LEG" EQUALIZING SLINGS

Entirely new design giving TWO SLINGS IN ONE. Sling legs lock automatically when lifting starts. Saves labour, time and accidents. Capacities from 1 ton to 20 tons.

BABY 60 ELECTRIC CHAIN BLOCKS

5 and 10-cwts. capacity. Light-weight, compact and portable. Push-button control. Upper and lower overtravel limit switches. Supplied for any height of lift to suit requirements. Top hook suspension facilitates fitting to travelling trolleys or girder clamps etc.

FELCO HOISTS LTD

29 CROMWELL ROAD, LONDON, S.W.7

Telegrams: 'FELCOHOIST' London Telex *Telex 24118*
Telephone: KENSINGTON 7401 (3 lines)

F3/60

BRITISH MADE — Patents Pending

High Speed + Flexibility

The Steadfast Flexible High Speed hacksaw blade is hardened on the teeth only by a new technique, giving cutting performance equal to the normal "all hard" high speed blade. At the same time it imparts a flexibility which enables the blade to be used by the unskilled, without fear of breakage.

The Steadfast Flexible High Speed blade will cut the toughest type of steel and withstands considerable mis-use, making it eminently suitable for "difficult" jobs which require flexibility allied to maximum cutting power.

For economy and efficiency, there is none better than the Steadfast Flexible High Speed blade.

Steadfast
FLEXIBLE HIGH SPEED

Available in the following sizes at the same prices as all other High Speed hacksaw blades.

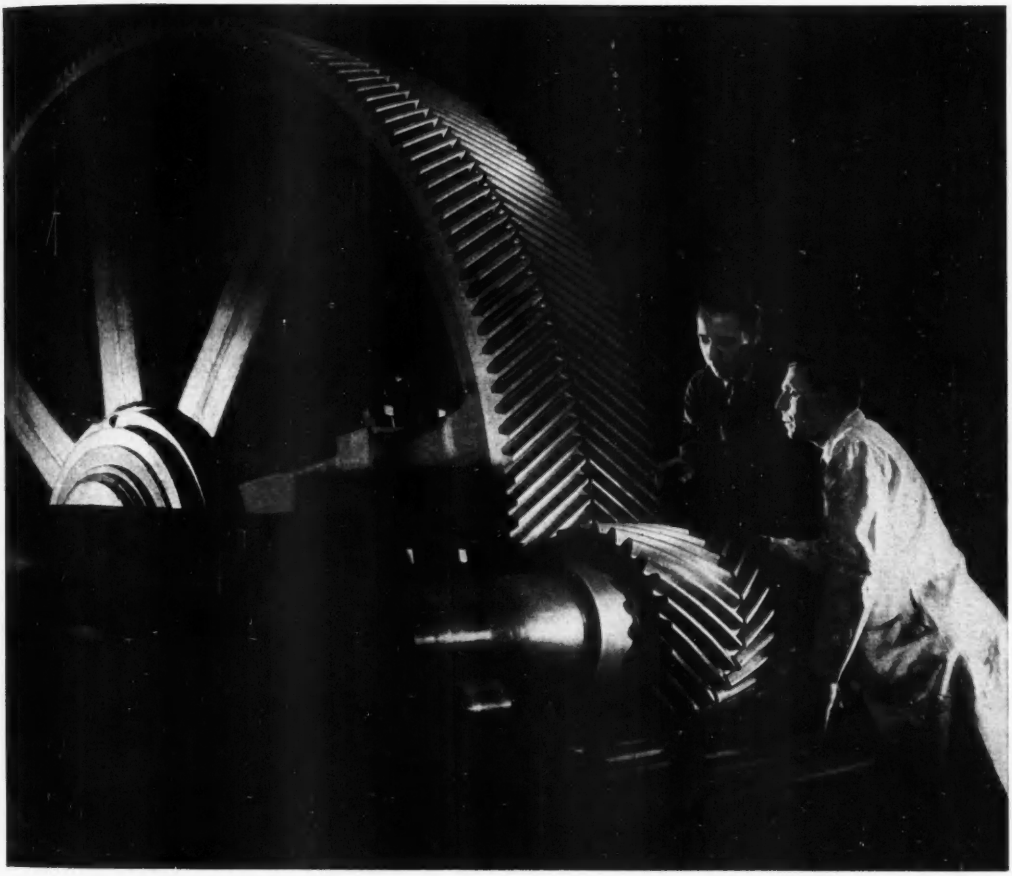
LENGTH	WIDTH	THICKNESS	PITCHES OF TEETH
10"	½"	·025"	18, 24, 32
12"	½"	·025"	14, 18, 24, 32

TOLEDO
DARWINS TOOL DIVISION
SHEFFIELD
Steadfast

DARWINS TOOL DIVISION

J. STEAD & CO. LTD. MANOR WORKS, SHEFFIELD, 2.

5133



Top Gears for Industry

The top gear to-day, of course, is made by David Brown — just as it has been for one hundred years. And there's a good reason for this universal approval of a famous name — for David Brown make the biggest range of gears in the country. Every one is fully proved and unsurpassed in its class for accuracy, quiet running and dogged dependability.

It adds up to this—more and more manufacturers are going straight into top with David Brown gears.

DAVID BROWN

THE DAVID BROWN CORPORATION (SALES) LIMITED.

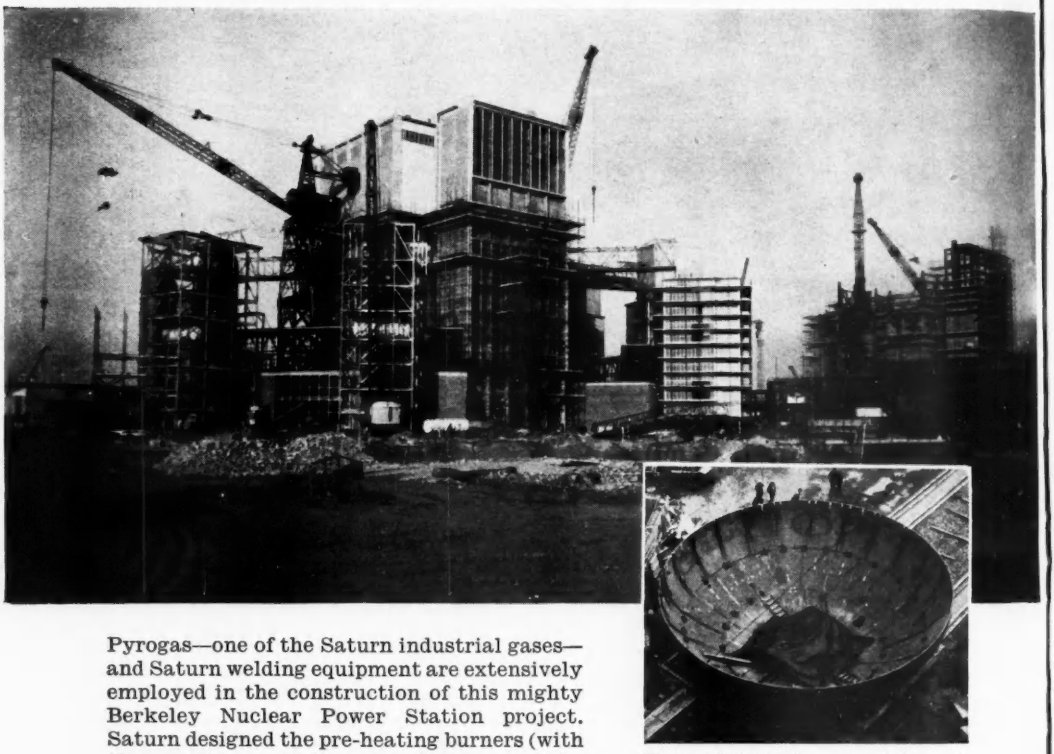
100 YEARS SERVING INDUSTRY 1860-1960

GENERAL GEAR DIVISION, PARK WORKS, HUDDERSFIELD. TELEPHONE: HUDDERSFIELD 3500

OA/6013

Pyrogas

AT BERKELEY NUCLEAR POWER STATION



Pyrogas—one of the Saturn industrial gases—and Saturn welding equipment are extensively employed in the construction of this mighty Berkeley Nuclear Power Station project. Saturn designed the pre-heating burners (with the assistance of the manufacturers, John Thompson Ltd.) . . . and supplied the burner parts for the Pyrogas/Air mixture prior to the rake burners, the hoses, regulators and the individual Torches.

Saturn also manufactured the 60 cylinder and 40 cylinder manifolds. Saturn is doing an important job at Berkeley—and on many other big industrial projects. Can we help you?

These photographs were taken at Berkeley Nuclear Power Station, which is being built for the Central Electricity Generating Board of Great Britain by A.E.I.—John Thompson Nuclear Energy Co. Ltd. In the smaller picture, the lower bowl of No. 1 Reactor vessel is being assembled in a temporary shelter, prior to being lifted into permanent foundations.

SATURN INDUSTRIAL GASES LTD

'Erl Wood', Windlesham, Surrey. Telephone: Bagshot 2441

Branches: LONDON GLASGOW ALDRIDGE BIRMINGHAM MANCHESTER SHEFFIELD LYMINGTON SUNDERLAND THORNABY-ON-TEES

SIG. 6

Rings and Circular Die Forgings

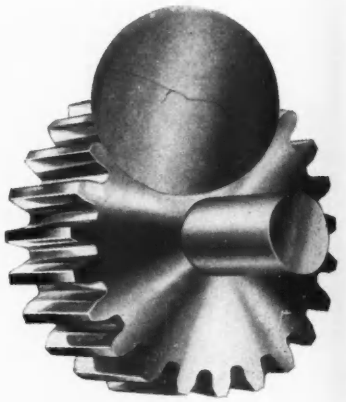
Seamless Rings in Carbon and Alloy Steels. Flanges of all types. Gear Rings and other rings with square, rectangular or profiled cross section, from 6 in. (minimum weight 70 lbs.) to 78 in. inside diameter and from 2 to 12 in. axial width. Circular Die Forgings, maximum weight 2,000 lbs.—Plain or punched slabs and special shaped forgings up to 40 in. diameter.

Taylor BROS. & CO. LTD

TRAFFORD PARK STEELWORKS, MANCHESTER 17

LONDON OFFICE: ST. ERMIN'S, CAXTON STREET, WESTMINSTER, S.W.1.

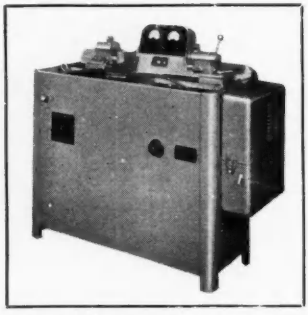
SURFACE CRACKS CAN KILL



Could YOU have detected this minute haircrack? The one infallible method of finding such minute but vital hair cracks is magnetic crack detection.

All Fel-Electric Universal Crack Detectors employ both the Current Flow and Magnetic Flux energizing circuits by the use of which, any component capable of being accommodated on the machine can be thoroughly checked for both longitudinal and transverse flaws respectively.

FEL-ELECTRIC Crack Detectors are easy to operate, save time, and are completely non-destructive. Their lack of moving parts means more reliability coupled with the backing of a highly efficient service organization.



If *you* have an inspection problem, or would like full details of the system, please write to Dept. C/D3.

**FELTIC Crack Detector Inks are supplied in Black, Red, Yellow, White and Fluorescent*

Ferrous and non-ferrous crack detection by

Contractors to H.M. Admiralty

This component was subjected to Fel-Electric magnetic check. A flaw was found and instantly shown up as a distinct black line. The machine used was the Universal 2/ET (illustrated left) which is suitable for parts up to 24 in. long. It employs both Current Flow and Magnetic Flux energizing circuits.

FEL-ELECTRIC LTD

SIDNEY STREET, SHEFFIELD 1. Phone: 27357

· Air Ministry · Ministry of Aviation

OA/5436

Another great advance, the

'CENTEC AUTOMIL'

suitable for

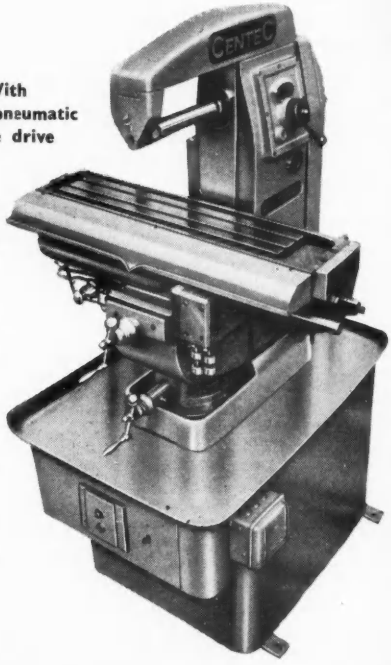
PENDULUM MILLING

USING TWO FIXTURES

14 inch TRAVERSE

With hydro-pneumatic table drive

Table surface **27 ins. × 6 ins.**



FOR LOW COST AUTOMATION

- Maximum efficiency when pendulum milling is achieved by providing a separately controllable feed rate in each direction.
- Idle time is reduced to an absolute minimum by having a fast traverse rate of 420 inches per minute.
- Great versatility of applications is achieved by a feed range from 1 inch to 400 inches per minute.
- Sturdy fixtures can be utilised because of the 14 inch table traverse.
- Maximum rigidity of the machine and minimum worker's fatigue is achieved by the low height of the table of the machine.
- Works on standard air line pressure.

OPTIONAL EXTRAS Auto-pneumatic index table, also vertical swivelling head.

Full details—

CENTEC MACHINE TOOLS LTD. • CENTEC WORKS • HEMEL HEMPSTEAD • HERTS • *Boxmoor 584-5-6*

ONE OF THE LARGEST FURNACE CONTRACTS PLACED IN RECENT YEARS IN EUROPE!

PETROCHEM-ISOFLOW FURNACES
at the new Botlek Refinery near Rotterdam, for Esso Nederland.

Birwelco were responsible for the design, supply and erection of the entire furnace installation, including the manifold piping. They also designed the ducting to the common stack situated at the centre of the installation. Overall Contractors for the complete refinery were Messrs. Badger, N.V.

THE INSTALLATION COMPRISES:

- ★ **A POWER FORMER CHARGE AND REHEATERS**
- ★ **STABILIZER, REBOILER AND FLUE GAS HEATERS**
- ★ **TWO FURNACES FOR THE HYDROFINER UNIT**

The largest furnace has a heat liberation of approximately 130 *million B.T.U.s per hour, with an overall diameter of approximately* 25 *feet.*

Many **PETROCHEM-ISOFLOW** installations are among the largest in the world; others are among the smallest. There are types for any capacity, duty or service. Whether of standard or special design, every Petrochem-Isoflow Furnace is SPECIFICALLY GUARANTEED FOR THERMAL PERFORMANCE.

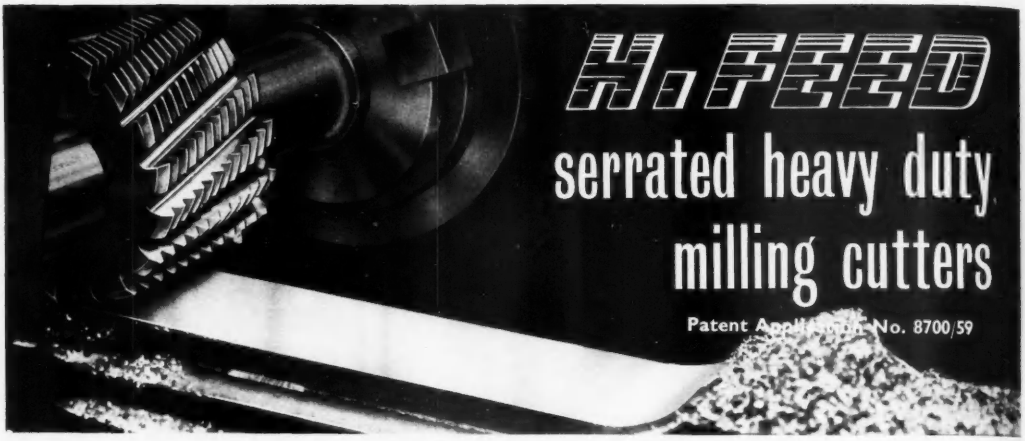
Engineered and Manufactured by BIRWELCO Ltd., in Great Britain and other parts of the world, under licence from the Petrochem Development Division of Yuba Consolidtaed Industries, Inc., USA.

BIRWELCO LTD.

CHESTER STREET, ASTON, BIRMINGHAM, 6.
Tel.: EASt 1171 (5 lines) Telegrams: BIRWELCO, B'HAM.

London Office: 46, Westminster Palace Gardens, S.W.1. Tel.: ABBey 2073 (3 lines)

Overseas AUSTRALIA: John Lysaght (Australia) Pty. Ltd., P.O. Newcastle 2N, N.S.W. Australia.
Associates GERMANY: Petrochem G.m.b.H., Düsseldorf, Tiergartenstrasse 45



HiFEED
serrated heavy duty milling cutters

Patent Application No. 8700/59

BRAYSHAW

TOOLS LTD.

BELLE VUE WORKS, MANCHESTER 12.

Telephone: EASt 1046 (3 lines)
Grams: Hardening M/c.

HiFEED serrated heavy duty cutters are designed to provide a combination of high rate of stock removal and good surface finish.

Some of the advantages to be obtained are:

SINGLE POINT CUTTING EFFICIENCY.

REDUCED LOAD AND VIBRATION on machine and work.

INCREASED PRODUCTION, particularly on work hardening and high tensile materials.

EFFICIENT HEAT DISSIPATION resulting from the break up of the cutting edges enables **HIGHER FEEDS AND SPEEDS** to be employed.

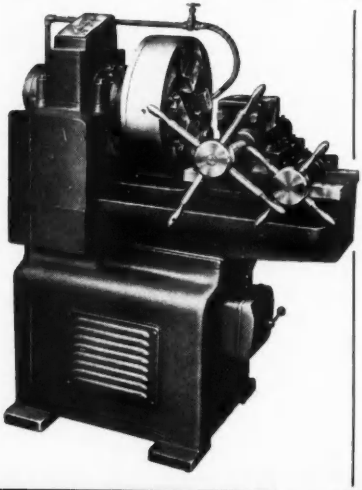
Primarily designed for heavy stock removal **HiFEED** cutters produce a surface finish acceptable for most applications. An alternative design, offering similar advantages plus superior surface finish when required is also available.

HiFEED cutters **INCREASE** production **REDUCE** costs.

Send to-day for your copy of leaflet No. S.T.603.

HEAP'S Patent Screwing Machines

Heap's Universal Screwing Machines are a range of General Purpose Screwing Machines widely used in general Engineering Workshops and Collieries and in the maintenance departments of factories etc. where the quantities of each class of screwing do not warrant the installation of the Automatic Diehead type of machine.



4" UNIVERSAL SCREWING MACHINE

This machine is fitted with a Stationary Tangential Diehead and Dies of High speed steel can be supplied for almost any type of thread. The vice is of the self-centring type with double jaws for the large sizes. Final drive to the main spindle is through a worm and worm wheel. Speed changes are obtained through "pick-off" gears. An automatic pump for the cutting lubricant can be supplied.

Capacity:

Pipes ..... ¼in. to 4in.
Bolts ..... ¼in. to 2 in.

JOSHUA HEAP & Co LTD ASHTON-UNDER-LYNE · ENGLAND

There's talk of Sykes in the control room

In this Space Age the need for fine pitch gears grows steadily — for missile guidance systems, rocket fuel pump drives, navigational aids, and a host of other applications. The design engineer nowadays is thus faced with many intricate problems — not only must gears for this type of work possess the highest degree of precision and reliability, but they must also often withstand very heavy tooth loadings, tremendous acceleration and extreme temperatures.

All the time, therefore, more exact and improved manufacturing methods are sought to increase the accuracy and surface finish of fine pitch gears.

Sykes have carried out immense research and development in these fields and are probably better placed than anyone else to advise on fine pitch gear generating and shaving on a production basis. In fact, Sykes are one of the few companies in the world offering tools for these purposes in the finest range, i.e. over 100 D.P.

With its unrivalled background of experience and knowledge, Sykes Technical Advisory Service has solved many customers' problems. Maybe a combination of Sykes gear generators and shaving machines could help you out of a difficulty. Anyway, if you would like an opinion . . .

Talk to SYKES about gear production

W. E. SYKES LTD · STAINES · MIDDLESEX · ENGLAND and associated companies: Sykes Tool Corporation Ltd, Georgetown, Ontario, Canada
Sykes Machine & Gear Corporation, Newark, NJ, USA
W. E. Sykes Ltd, Mascot, Sydney, NSW, Australia

ZEISS

UNIVERSAL MEASURING MICROSCOPE

This instrument will solve practically any measuring problem likely to be encountered at the present time. It is also the only measuring instrument on which all the parameters of a plug screw gauge can be measured directly without rechucking the test piece. A wide range of dial-templet oculars can be provided.

SPECIAL FEATURES

● **Extreme accuracy** ● **Built in dividing head** ● **Projection equipment available** ● **Wide range of accessories** ● **Photographic attachment** ● **Magnifications 10 × to 50 ×**

Please write for details to :

CARL ZEISS JENA

C. Z. Scientific Instruments Limited
12a Golden Sq. London, W.1. Tel: Gerrard 4488

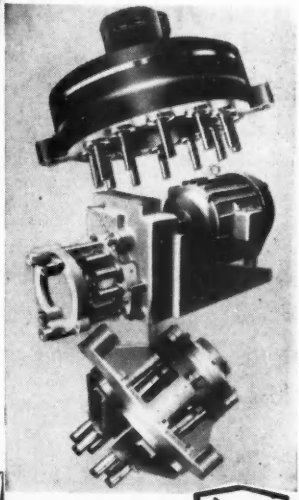
CONSULT SPK

the experienced multi-drilling specialists

Slack & Parr manufacture the largest range of multi-heads for standard drilling machines and unit heads. Whether your problem is drilling two holes or fifty holes, there is an S.P.K. head available for either small batch production or long runs. S.P.K. equipment can be supplied complete with jigs ready to start immediate production.

The capital outlay is quickly recovered due to increased production. All S.P.K. multi-drilling equipment is built from standard off-the-shelf components developed from practical experience. For low cost and proved performance, you cannot better S.P.K. equipment for all your multi-drilling.

Tell us your production problems—they may not be problems to us.

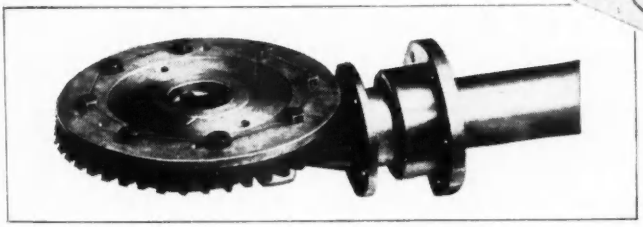


SLACK & PARR LIMITED
KEGWORTH . Nr. DERBY
Telephone: Kegworth 306

NICKEL ALLOY STEELS

ensure reliability in loading

Samson Loader Model MC3



Bevel pinion and crown wheel assembly for gathering head.

Economical coal production depends upon rapidly removing coal or stone when it has been brought down. To do this the Samson Loader has been developed by Mavor and Coulson Ltd., Bridgeton, Glasgow, S.E.

The Samson Loader is essentially a flexible conveyor on to which two gathering arms quickly pull loose material. The delivery end of the jib can be varied from 2 ft 1 in to 8 ft 4 in high, and peak capacity working for Model MC3 is up to 5 tons of coal per minute.

To achieve reliability under the difficult conditions in coal mines, the designers specified nickel alloy steels notably En25, En36B and En24 or equivalents for high impact values. These steels are used for gear shafts and other components.

TYPICAL MECHANICAL PROPERTIES OF

EN25

These illustrate its strength and toughness in massive sections

SIZE	HEAT TREATMENT	YIELD STRESS t.s.i.	MAXIMUM STRESS t.s.i.	ELONGATION per cent	IZOD ft. lb.
2½ in. dia.	Oil quenched 830 °C. tempered 590 °C.	75	78	17	44
2½ in. dia.	Oil quenched 830 °C. tempered 650 °C.	58	63	21	68
4 in. dia.	Oil quenched 830 °C. tempered 650 °C.	56	61	21	69
6 in. dia.	Oil quenched 830 °C. tempered 650 °C.	55	61	22	63

By utilising the better properties obtainable in nickel alloy steels, dimensions can be reduced, lighter constructions produced, distortion through heat-treatment minimised and reliability and economy achieved.

Please send for our publications entitled, 'The Mechanical Properties of Nickel Alloy Steels' and 'The Case Hardening of Nickel Alloy Steels'.

MOND NICKEL

THE MOND NICKEL COMPANY LIMITED, THAMES HOUSE, MILLBANK, LONDON, SW1

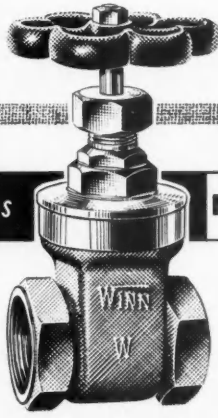
YGA 21/5/1D

IN THE

WINN

TRADITION

a new range of **solid wedge gate valves** **N°1320**



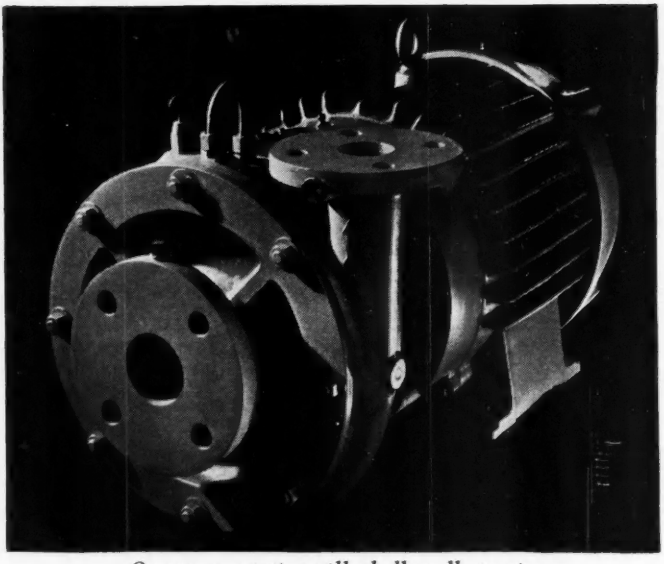
A new range of solid wedge gate valves combining the quality tradition of the more expensive types with the benefits of automatic production techniques.

Suitable for Steam up to 125 p.s.i. Water up to 200 p.s.i. Made from hard cast bronze of the WINN special formula. Sizes ¼" to 2". Delivery from stock.

Full details on request.

CHARLES WINN & CO., LTD.
valve makers for 100 years

GRANVILLE STREET,
BIRMINGHAM 1.
Telephone: MIDland 7151 (10 lines)
Telegrams: Winn, Birmingham



Our representative will gladly call to give technical advice on particular applications. For full details please write to :

Head Office and Home Sales: Park Works, Stamford, Lincs.
Telephone No. Stamford 2552 (9 lines). Telegrams: "Arleoco" Stamford.

Alcon
introduces the new
Thames
range of centrifugal
Pumps

Outputs up to 500 gallons per minute

This is a sister range to the famous Alcon Self-priming Centrifugal Pumps

NEWAGE GROUP

The symbol of the Newage Group is the hall-mark of first-class engineering
"Stamford Alternators"
"ALCON self priming pumps"

Export Sales:
6 Carlos Place, Grosvenor Square, London, W.1. Hyde Park 9141.

A single strainer of the type we supply to the C.E.G.B. handles five million gallons of water an hour—enough to maintain quite a spectacular waterfall. At Aberthaw Power Station there are six such units with a total capacity of 30,000,000 g.p.h. straining the condenser cooling water.

Richardsons Westgarth rotary strainers are made in a range of sizes from 160,000 g.p.h. to 5,000,000 g.p.h., they are self cleaning, operate continuously, and the accumulated sludge is blown out at intervals without interrupting the flow.

Please write for illustrated brochure.

RICHARDSONS WESTGARTH (HARTLEPOOL) LTD.

A member of the RICHARDSONS WESTGARTH GROUP

HARTLEPOOL, CO. DURHAM AND AT 58 VICTORIA STREET, LONDON, S.W.1.
59 MOSLEY STREET, MANCHESTER, 75 BUCHANAN STREET, GLASGOW

RW 59

Flash Welding . . .

. . . Extraordinary . . .

. . . up to 15 sq. ins. in Mild Steel, 6 sq. ins. in Titanium Alloys: up to 5 sq. ins. in "Nimonic" 75 and 2 sq. ins. in "Nimonic" 90!

Complete uniformity of weld quality and accurate tolerances minimise machining and improve yield. Reynolds Flash Welding facilities include machines of up to 60 tons upset capacity.

Write for literature F.W.11

REYNOLDS

REYNOLDS TUBE CO. LTD TYSELEY BIRMINGHAM 11

E.13

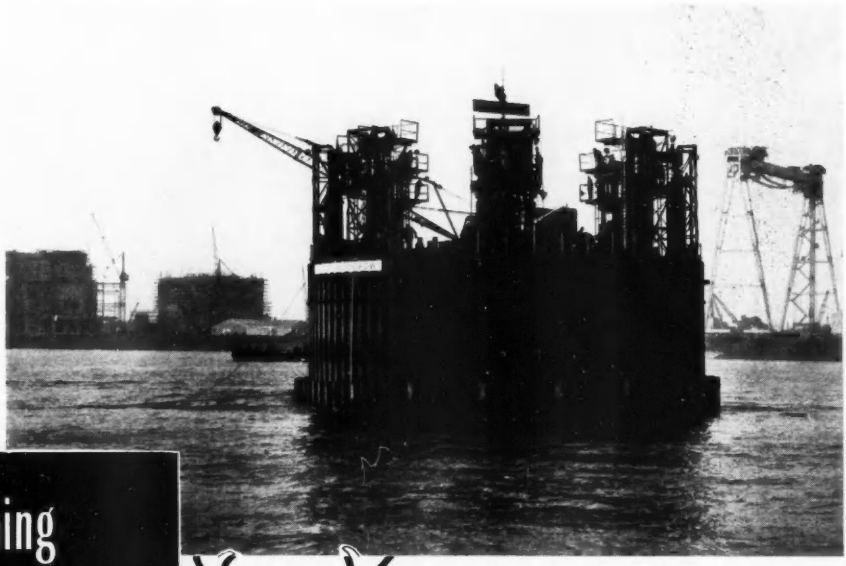
PRESSINGS

If you require pressings consult Ward (Metal Details) Ltd. We are specialists in the manufacture of all types of small and medium pressings of any shape, size and thickness, in steel, tinplate, copper etc. from which complete assemblies can be fabricated by welding, soldering or brazing.

Illustrated here are some examples of our products, and similar components can be produced to your own specification and design, and supplied in painted, plated or enamelled finishes.

WARD
(METAL DETAILS) LTD.

DARLASTON · STAFFS



Keeping out of trouble.. at Hinkley Point

. . . . . under construction for Central Electricity Generating Board by the English Electric, Babcock and Wilcox and Taylor Woodrow, Atomic Power Construction Company Limited.

When Taylor Woodrow positioned this 3,900 ton caisson accurately above the tunnel being drilled under the rock below, the correct distribution of the loads to the structure as it settled on the bed of the Bristol Channel was of paramount importance.

Saunders-Roe strain gauge engineers provided a simple electrical system for measuring the loads in the spud legs.

This is but one example of the way in which Saunders-Roe foil strain gauge techniques requiring only simple electrical measuring instruments are contributing to research development and every day instrumentation over an almost boundless field of industrial activity.

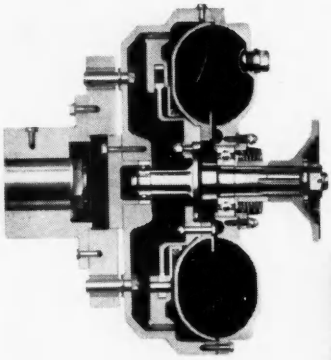
For full details write to:—

SAUNDERS — ROE

STRAIN GAUGE DIVISION

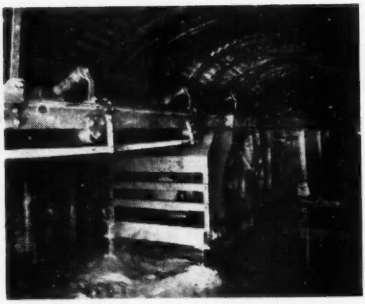
OSBORNE · EAST COWES · ISLE OF WIGHT

A member of the Westland group of companies



The FLUID FRICTION CLUTCH for ELECTRIC MOTOR DRIVES

This conveyor built by Richard Sutcliffe Ltd., is one of many fitted with the Fluid Friction Clutch.



The fluid friction clutch combines a fluid and centrifugal coupling, utilising the best of each type. It provides a really smooth take up from rest while the centrifugal element ensures a positive drive with cool running. With the fluid clutch the electric motor is permitted to accelerate to its full speed in the shortest possible time and the current quickly falls to a safe value while the load is accelerating under the influence of a substantial torque.

Write for details of this interesting unit

SELF-CHANGING GEARS LTD

Patentees and makers of 'Wilson' Gearboxes

LYTHALLS LANE · COVENTRY · ENGLAND

NITRIDED *Nitralloy* STEELS

The Nitriding Process for Case-hardening Special Steels by Nitrogen Offers

- **Surface hardness up to 1100 D.P.H.**
- **Retention of full hardness after heating to 500°C.**
- **Maximum resistance to frictional wear and fatigue.**
- **Improved resistance to corrosion by water and steam.**

Particulars from:—

NITRALLOY LIMITED ATLAS WORKS SHEFFIELD, 4.

Telephone: Sheffield 26646. *Telegrams: "Nitralloy, Sheffield"*

Temperature Measurement

"Thermindex" Paints are temperature sensitive compounds which indicate by a sharp, clear cut change of colour when the temperature of a surface has attained or exceeded a predetermined value, so that information on the temperature of an entire surface is given at a glance.

Write Dept. KL/10 for full technical details.

"THERMINDEX"

TEMPERATURE INDICATING PAINTS

SOLE DISTRIBUTORS FOR EUROPE AND THE U.K.

J. M. STEEL & CO. LTD.

38-38 KINGSWAY, LONDON, W.C.2

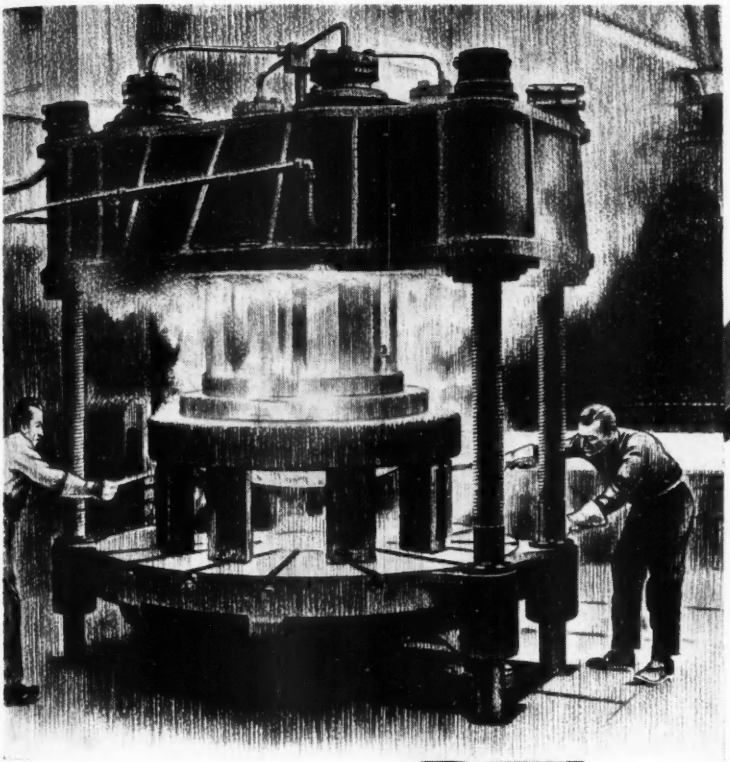
Tel. : HOLborn 2532/5

Branch Offices

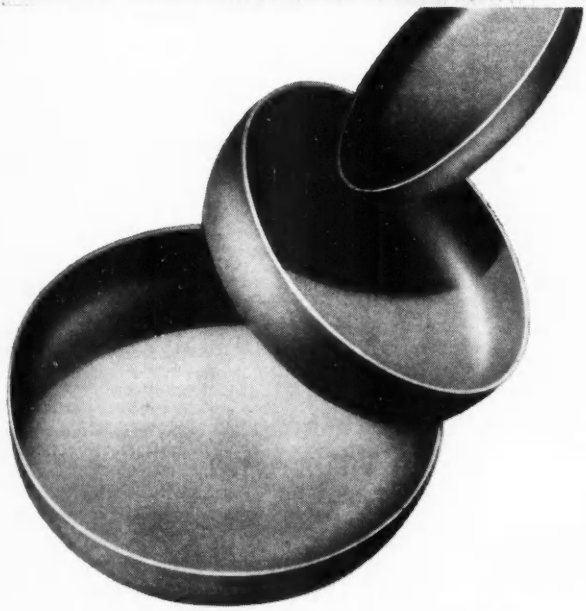
51 SOUTH KING ST., MANCHESTER 2
Tel. : Deansgate 6077/9

45 NEWHALL ST., BIRMINGHAM 3
Tel. : Central 6342/3

Manufactured by Synthetic & Industrial Finishes Ltd.



DISHED and FLANGED ENDS



Fabrication of pressure vessels may be greatly facilitated by drawing upon Harvey resources for the production of die-pressed Dished and Flanged Ends.
Capacities range from 6 in. to 9 ft. diameter. Edges are prepared for welding or riveting if desired.

STOCK SIZES: Ends pressed from Boiler Quality or Ship Quality Mild Steel up to $\frac{1}{2}$ in. thickness, in most sizes up to 7 ft. diameter, are normally available from stock.

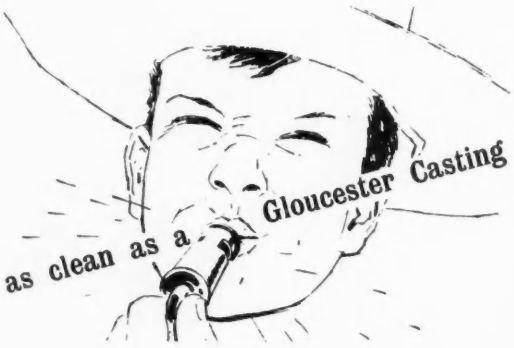
SEMI-ELLIPSOIDAL HEADS can be produced on the Rotarpress; diameters 5 ft. to 15 ft.; thicknesses $\frac{3}{8}$ in. to 4 in.

For details, please ask for List No. ED 1049

HARVEY

G. A. HARVEY & Co. (LONDON) LTD., Woolwich Road, London, S.E.7. Phone: GREenwich 3232 (22 lines)

HF/LF/2



"As clean as a Gloucester Casting" means that Gloucester malleable iron castings are of high definition, true to pattern, cleaner and smoother because of better sand practice and better fettling.

Mould and core sands and their bonding additives are under constant laboratory supervision, even the very sand grains are sized and numbered, and consistency and distribution of sand are strictly controlled by a continuous mechanical unit. The high refractory characteristics prevent sand "burn-on" at re-entrant angles, thus greatly increasing the life of cutting tools during the machining process. The new elevator-type electric furnace anneals in 48 hours—instead of the usual 7 days. It also allows greater control of the component during annealing, resulting in uniformity of metal, greater strength, and resistance to impact.

A typical Gloucester Malleable specification.

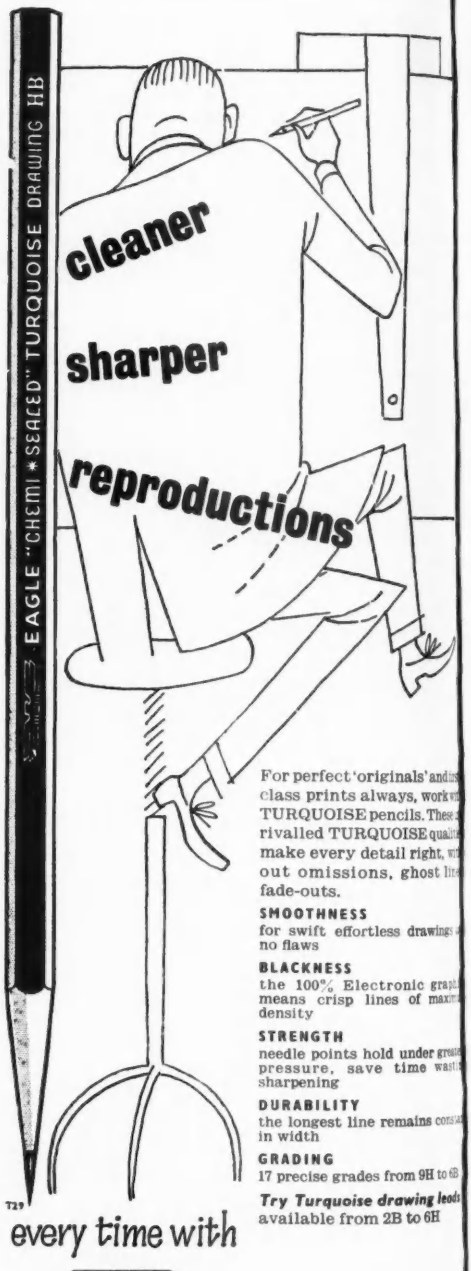
Gloucester Blackheart Malleable	*Gloucester Lamellar Pearlitic Malleable*
Elongation .. 18%	Elongation .. 5%
Yield Point .. 12 tons	Yield Point .. 24 tons
Tensile Strength 25 tons psi	Tensile Strength 35 tons psi

Brake shoe for small vehicle in Malleable Iron

Bearing bracket in Malleable Iron. Weight 3¼ lbs.

GLOUCESTER

Gloucester Foundry Ltd., Emlyn Works, Gloucester
Telephone: Gloucester 23041. Telegrams: 'Pulleys' Gloucester
(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)



For perfect 'originals' and
class prints always, work
TURQUOISE pencils. These
rivalled TURQUOISE quali
make every detail right, w
out omissions, ghost li
fade-outs.

SMOOTHNESS
for swift effortless drawing
no flaws

BLACKNESS
the 100% Electronic grap
means crisp lines of maxi
density

STRENGTH
needle points hold under gra
pressure, save time wa
sharpening

DURABILITY
the longest line remains cons
in width

GRADING
17 precise grades from 9H to 6

Try Turquoise drawing leads
available from 2B to 6H

T29

every time with

TURQUOISE pencils

9d each
8/6d per dozen

EAGLE PENCIL COMPANY • ASHLEY ROAD • TOTTENHAM

Why are they smiling?

—they've discovered R.T.D!

R.T.D.?—the new extreme pressure lubricant by Rocol Limited for drilling, reaming, and tapping tough stainless and alloy steels, nickel and titanium. It's not just an additive — but a complete lubricant in itself.
See what actual users have to say about R.T.D. Compound.

PRODUCTION MANAGER
"Before R.T.D., tapping S62 stainless steel with a 5/16 inch B/S. Pipe Thread was causing a permanent bottleneck in production. Now I never even have to think about it."

OPERATIVE
"A bit rough, being on piece rates and having one in five rejected, not to mention all the hold-ups for machine servicing, but with R.T.D. I can work fast right through the shift without a sign of trouble."

MACHINE TOOL FITTER
"Spent more time on that machine than all the others in the shop. Now with R.T.D. tool life has gone up by as much as 200%."

INSPECTOR
"Nobody likes to reject as much as 20% of a man's work, but because of inferior surface finish I had no option. But with the introduction of R.T.D. rejections fell to 5% overnight."

SALES REPRESENTATIVE
"Production difficulties not only forced our price up but caused delivery delays as well. Now with R.T.D. we're ahead of our competitors on both price and delivery."

Try R.T.D. Compound for yourself. ***Send for a free trial sample today*** *and see the instant improvement that it brings!*

R.T.D COMPOUND

A Rocol PRODUCT

ROCOL LIMITED
General Buildings · Aldwych · London W.C.2 · Tel: HOLborn 1985.
Rocol House · Swillington · Nr. Leeds · Tel: Garforth 2261.

That high speed feeling

KERAUNOS High Speed Steel Hacksaw Blades offer exceptional wear-resistance in cutting hard and tough materials such as Nickel-Chrome Steels, Stainless Steels, Tool and Gauge Steels

with

KERAUNOS

Hacksaw Blades.

Write for your copy of our new helpful booklet "What you should know about Hacksaw Blades" and see how you can effectively improve production and reduce machining costs by using KERAUNOS High Speed and PAX Low Tungsten Hacksaw Blades

SANDERSON BROTHERS AND NEWBOULD LIMITED

Attercliffe Steelworks, P.O. Box 6, Newhall Road, Sheffield 9

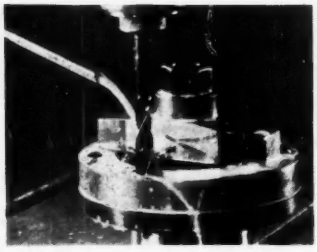
ABRASIVE BELT MACHINES

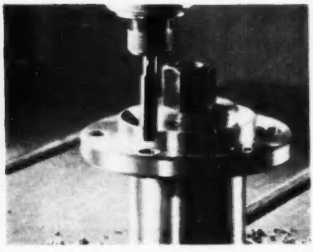
B. O. MORRIS LTD. • MORRISFLEX WORKS, BRITON ROAD • COVENTRY

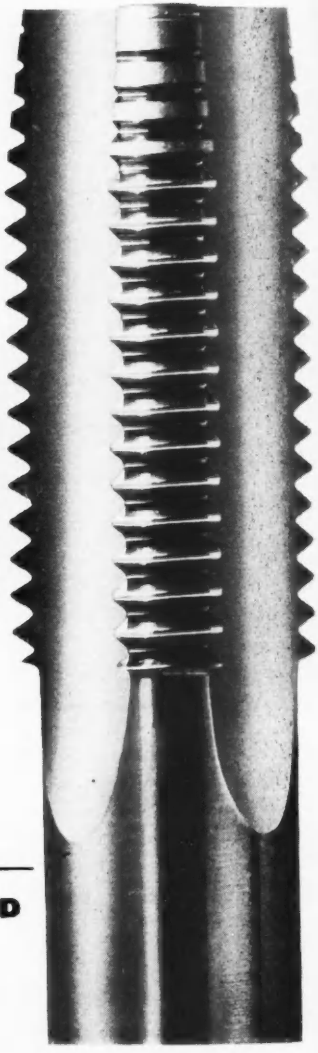
Telephone : 53333 (PBX) Telegrams : MORISFLEX, COVENTRY

PRODUCT OF THE Morrisflex GROUP

Drill and Tap with EaSiCut







"Easicut" high speed steel Drills and Taps offer the ideal combination of accuracy, high cutting speeds and reliable performance.

ESC

ENGLISH STEEL TOOL CORPORATION LTD

North Street Works, Openshaw, Manchester

A wholly owned subsidiary of English Steel Corporation Ltd Sheffield

Stocks also held at : 167 Dukes Road, Acton, London, W.3.; 62-64 Scotswood Road, Newcastle; 2181 Coventry Road, Sheldon, Birmingham 26; Holme Lane Works, Sheffield.

Index of Current Advertisers and their Advertising Agents

Abacas Engineering Co. Ltd. —
Agency—McConnell & Co. (Adv.) Ltd.
Ackworthie, John, Ltd. —
Agency—Biddle Bros. Ltd.
Acru Electric Tool Mfg. Co. Ltd. —
A.E.I.-Birlec Limited —
Agency—Sandbrook, Metcalf & Co. Ltd.
Air Industrial Developments Ltd. —
Agency—Nicholls, Dorrity Adv. Ltd.
Airmec Limited —
Agency—D. J. Mackridge & Partners Ltd.
Allen, Edgar & Co. Ltd. 54
Agency—Rowlinson Broughton Ltd.
Allen, W. H., Sons & Co. Ltd. —
Allspeeds Ltd. 7
Agency—Hyde & Partners Ltd.
Alumilite & Alzak Ltd. 16
Agency—Beresford Bourke Ltd
Angus, George, & Co. Ltd. 31 & 56
Agency—Redheads Adv. Ltd.
Archdale, James, & Co. Ltd. 65
Armstrong Patents Co. Ltd. 14
Agency—Pickersgill Publicity Service Ltd
Armstrong Siddeley (Brockworth) Ltd. —
Agency—Young & Rubicam Ltd.
Armstrong, Stevens & Son Ltd. —
Agency—Boswell, Barratt & Phillips Ltd.
Associated Electrical Industries Ltd. —
Agency—T.G.A. Ltd.
Atlas Plating Works Ltd. —
Agency—White & Carter Ltd.
Automotive Engineering Ltd. 29
Agency—T. B. M. Advertising Ltd.
Automotive Products Co. Ltd. —
Agency—H. Raymond Morgan
Avo Ltd. —
Agency—National Publicity Co. Ltd.

B.I.P. Chemicals Ltd. —
Agency—Central News Ltd.
B.R.C. Engineering Co. Ltd. 32
Agency—Murray Watson Ltd.
B.S.A. Tools Ltd. —
Bailey, Sir W. H., & Co. Ltd. —
Agency—T.G.A. Ltd.
Bakelite Ltd. 111
Agency—T.G.A., Co. Ltd.
Balfour, Arthur, & Co. Ltd. 8 & 9
Agency—Charles Stanley & Partners Ltd.
Beakbane, Henry (Fortox) Ltd. —
Bennett (Hyde) Ltd. —
Agency—John Willis Adv. Ltd
Benton & Stone Ltd. 13
Agency Longleys & Hoffmann Ltd.
Berardi, Rino. 41
Birfield Group 35, 39, 80
Agency—Central News Ltd.
Birwelco Ltd. 157
Agency—Grosvenor Advertising Ltd.
Boldrini —
Borg & Beck Co. Ltd. —
Agency—H. Raymond Morgan
Bound Brook Bearings Ltd. 39
Agency—Central News Ltd.
Brammer, H. & Co., Ltd. 138
Agency—Harrisons Adv. Ltd.
Brayshaw Tools Ltd. 158
Agency—Ingham Butterworth Ltd.
Bristol Siddeley Engines Ltd. 122
Agency—Young & Rubicam Ltd.
British Bellows— —
Agency—Elliott Advertising Ltd.
British Electric Resistance Co. Ltd. 146
Agency—John Collings & Partners Ltd.
British Federal Welder & Machine Co. Ltd. —
Agency—Press & General Publicity Service Ltd.
British Manzel Oil Pump Co. —
British Paints Ltd. 139
Agency—Redhead s Adv. Ltd.
British Power Transformer Co. Ltd. —
Agency—John Collings & Partners Ltd.
British Resin Products Ltd 109
Agency—T. G. Scott & Son Ltd.
British Rolling Mills Ltd. 2
Agency—Maurice G. Parker Ltd.
British Rototherm Co. Ltd., The —
Agency—Pitchford's Advertising Ltd.
British Timken: Division of The Timken Roller Bearing Co. —
Agency—H. Raymond Morgan
Broadbent & Co. (Rochdale) Ltd. —
Agency—Arthur Burns Publicity
Brockhouse, J., & Co. Ltd. 24
Agency—A. N. Holden & Co. Ltd.
Broom & Wade Ltd. —
Agency—Stephens Adv. Service Ltd.

Brotherhood, Peter, Ltd. —
Agency—J. Peers & Assocs. Ltd.
Brown, Boveri & Co. Ltd. —
Brown, David, Corporation (Sales) Ltd. 72 & 53
Agency—Oelrichs Advertising Ltd.
Brown Fintube (Great Britain) Ltd. —
Agency—Grosvenor Advertising Ltd.

Caldwell, T., & Son Cover 2
Castings Ltd. —
Agency—Rowlinson Broughton Ltd.
Centec Machine Tools Ltd. 156
Agency—Applied Designs Adv. Ltd.
Chapman & Hall Ltd. —
Chatwin, Thomas, & Co. —
Agency—A. N. Holden & Co. Ltd.
Chesterfield Tube Co. Ltd. —
Agency—C. B. Casson Ltd.
Churchill, Charles, & Co. Ltd. 95
Agency—Technical Advertising Service Ltd.
Churchill Machine Tool Co. Ltd., The 46
Agency—Associated British Machine Tool Makers Ltd.
Clayton-Wright, Howard Ltd. —
Agency—Don Earl Publicity Ltd.
Colt Ventilation Ltd. 45
Agency—Greenlys Ltd.
Consolidated Pneumatic Tool Co. Ltd. 143
Agency—Hyde & Partners Ltd.
Coppier Fratelli 42
Cory Bros. & Co. Ltd. —
Agency—Hyde & Partners td.
Coulthard, Wm., & Company Ltd. 30
Counting Instruments Ltd. —
Agency—Walkley Hodgson Ltd.
Cradley Boiler Co. Ltd. 176
Agency—Riley Advertising Ltd.
Crane Packing Ltd. 110
Agency—J. Ainsborough Everiss & Assocs.
Crofts (Engineers) Ltd. 76
Cronite Foundry Co. Ltd., The Cover 2
Crowthorn Engineering Co. Ltd. 36
Agency—J. K. Clayton Advertising Ltd.
C. Z. Scientific Instruments Ltd. 160
Agency—Oatley Webster Ltd.

Dart Spring Co. Ltd. —
Agency—Beardmore Adv. Ltd.
Darwins Ltd. 152
Agency—Apex Advertising Ltd.
Dawson Bros. Ltd. 150
Agency—Collinson's Adv. Agency Ltd.
Dick, R. & J., Ltd. Cover 4
Agency—Rex Publicity Ltd.
Doncaster, Daniel & Sons Ltd. 12
Agency—Rowlinson Broughton Ltd.
Dowty Seals Ltd. 15
Agency—Hamill Toms Ltd.

Eagle Pencil Co. 168
Agency—Saward Baker & Co. Ltd.
Eastman Chemical Products Ltd. 137
Agency—Fred. Wittner Company
Elcontrol Ltd. 140 & 141
Agency—Fdk. E. Potter Ltd.
Electrical Development Association —
Agency—Mather & Crowther Ltd.
Electric Resistance Furnace Co. Ltd. Cover 1
Agency—Nigel Rainbow & Partners Ltd.
Electrical Power Engineering Co. (B'ham) Ltd. 58
Agency—Nicholls, Dorrity Advertising Ltd.
Electro-Dynamic Construction Co. Ltd. —
Agency—J. Peers & Associates Ltd.
Elliott, B. (Machinery) Ltd. —
Agency—Nigel Rainbow & Partners Ltd.
Elliott, E., Ltd. 115
Agency—Sterling Advertising Ltd.
Empire Rubber Company —
Agency—Robt. Sharp & Partners Ltd.
Empyrium Welding & Mfg. Co. Ltd. 145
Agency—Jack White & Assocs. Ltd.
English Electric Co. Ltd., The 70
Agency—Technical Advertising Service Ltd.
English Steel Tool Corporation 172
Agency—T.G.A. Ltd.
E.N.V. Engineering Co. Ltd. 50
Agency—Allardyce Palmer Ltd.
Evans, Joseph & Sons (Wolverhampton) Ltd. 18
Agency—Sterling Advertising Ltd.
Evertaut Ltd. 44
Agency—Elliott Adv. Ltd.

Fafnir Bearing Co. —
Agency—H. Raymond Morgan
Fel-Electric Ltd. 156
Agency—Oelrichs Advertising Ltd.

Felco Hoists Ltd. 151
Agency—Clinton-Wall Ltd.
Fenner, J. H., & Co. Ltd. 17
Agency—Hyde & Partners Ltd.
Firth-Derihon Stampings Ltd., The —
Agency—Stanley D. Dickson
Firth, Thos., & John Brown Ltd. 78
Agency—Stanley D. Dickson
Flame Hardeners Ltd. —
Ford Motor Co. Ltd. 53
Agency—Rumble Crowther & Nicholas Ltd.
Fraser, Andrew, & Co. Ltd. —
Agency—J. Peers and Associates Ltd.

Gear Grinding Co. Ltd. —
Agency—Sandbrook Metcalfe & Co. Ltd.
General Electric Co. Ltd. 114
Agency—Greenlys Ltd.
Glacier Metal Co. Ltd. —
Agency—Notley Advertising Ltd.
Gloucester Foundry Ltd. 168
Agency—Print for Industry Ltd.
Griffiths, Gilbert, Lloyd & Co. Ltd. —
Agency—Nicholls, Dorrity Advertising Ltd.
Guest, Keen & Nettlefolds (Midlands) Ltd. 33
Agency—Notley Advertising Ltd.

Hackbridge & Hewittic Electric Co. Ltd. —
Agency—Industrial Publicity Service Ltd.
Haddon, Thomas, & Stokes Ltd. —
Hadfields Ltd. 21
Hallmac Tools Ltd. 4 & 5
Agency—Jack White & Associates
Hancock & Co. (Engineers) Ltd. —
Agency—Tibbenham Publicity Ltd.
Harcourt, David, Ltd. —
Agency—Allardyce Palmer Ltd.
Hardy Spicer Ltd. —
Agency—Central News Ltd.
Harper, John, & Co. Ltd. 37
Agency—Rowlinson-Broughton Ltd.
Harris Tools, John, Ltd. —
Agency—Sandbrook, Metcalf & Co. Ltd.
Harvey, G. A., & Co. (London) Ltd. 167
Agency—G. P. Hughes Ltd.
Hawker Siddeley Brush Turbines Ltd. —
Agency—G. Street & Co. Ltd.
Heap, Joshua, & Co. Ltd. 158
Heathrod Ardwyn & Co. Ltd. —
Agency—Severn Publicity Ltd.
Heenan & Froude Ltd. —
Agency—Kenley Advertising Ltd.
Herbert, Alfred, Ltd. —
Hermetic Rubber Co. Ltd. —
Hilger & Watts Ltd. 68
Agency—Crane Publicity Ltd.
Hoffmann, Mfg. Co. Ltd., The —
Holden, Arthur, & Sons Ltd. —
Agency—S. D. Toon & Heath Ltd.
Holroyd, John, & Co. Ltd. 148 & 149
Agency—C. R. Casson Ltd.
Horstmann Gear Co. Ltd., The —
Agency—Trowbridge Pritchard & Co. Ltd.
Howard, Stanley Ltd. —
Agency—Sterling Adv. Ltd.

I.C.I. (Plastics) Ltd. 113
Agency—S. H. Benson
Ideal Fabbrica Italiana Trapani 138
Imperial Chemical Industries Ltd. —
Agency—Clifford Martin Ltd.
Industrial Fan & Heater Co. Ltd. —
Agency—Sinclair Advertising Ltd.
Industrial Mouldings (Warwick) Ltd. 108
Agency—L. Graham & Browne Adv. Ltd.
Ingersol-Rand Co. Ltd. —
Agency—J. Peers & Associates Ltd.
Innocenti —
Instrument Screw Co. Ltd. —
Agency—Technical Advertising Service
Intermic Limited 35
Agency—Central News Ltd.
International Meehanite Co Ltd., The —
Isopad Ltd. —
Agency—E. W. Barney Ltd.

Jacobs Mfg. Co. Ltd. —
Agency—Crane Publicity Ltd.
Jenkins, Robert, & Co. Ltd. 69
Agency—W. Hopwood & Co. Ltd.
Jerguson Tress Gauge & Valve Co. Ltd. —
Agency—J. Peers & Associates Ltd.
Jet-Lube Ltd. —
Johnson Foster, H., Ltd. —
Agency—Pickersgill Publicity Service Ltd.

SPARK MACHINING PRODUCES INTRICATE SHAPES LIKE THIS-IN INTRACTABLE MATERIALS-ECONOMICALLY AND FAST

If you want to know more about the GKN spark machine write to our U.K. agents

M. C. LAYTON LIMITED, ABBEY WHARF, MOUNT PLEASANT, ALPERTON, WEMBLEY, MIDDX · RUDKIN & RILEY LIMITED, CYPRUS ROAD, AYLESTONE, LEICESTER

MANUFACTURED BY WELSH METAL INDUSTRIES LTD., CAERPHILLY, GLAMORGANSHIRE

A MEMBER OF THE GKN GROUP OF COMPANIES

Index (*continued*)

Johnson Precision Instruments (Newman Granger) Ltd. —
Agency—Rex Publicity Service Ltd.
Jones, A. A., & Shipman Ltd. 142
Agency—Sterling Advertising Ltd.
Jones, E. H. (Machine Tools) Ltd. 112
Agency—Nigel Rainbow & Partners Ltd.

Kayser, Ellison, & Co. Ltd. 51
Agency—Stowe & Bowden Ltd.
Keelavite Hydraulics Ltd. —
Agency—Cogent Advertising Service Ltd.
Kendall & Gent Ltd. —
Agency—Associated British Machine Tool Makers Ltd.
Kenilworth Manufacturing Co. Ltd. 136
Agency—Crossley & Co. Ltd.
Klinghofer, E. & C. —

Lancashire Dynamo & Crypto Ltd. —
Agency—John Mitchell & Partners Ltd.
Lang Pneumatic Ltd. 71
Agency—J. Peers and Associates Ltd.
Laycock Engineering Ltd. 80
Agency—Central News Ltd.
Lewis Spring Co. Ltd., The 26
Agency—Longleys & Hoffmann Ltd.
Lewis & Tylor Ltd. —
Agency—Glovers Advertising Ltd.
Ley's Malleable Castings Co. Ltd. —
Agency—H. Raymond Morgan
Lincoln Electric Co. Ltd. —
Agency—London Press Exchange Ltd.
Livet 20
Lodge Plugs Ltd. —
Agency—Elliott Advertising Ltd.
Lomount Vehicles & Engg. Ltd. 27
Agency—City & General Advertising Ltd.
Lusardi, E. —
Lyon, Arthur, & Co. (Engineers) Ltd. 162
Agency—Howard Pantor Ltd.

Magnetic Valve Co. Ltd., The —
Agency—John Westwood Ltd.
Meddings, W. J., Ltd. —
Agency—Ripley, Preston & Co. Ltd.
Menrow Limited —
Agency—Ripley, Preston & Co. Ltd.
Mercedes-Benz 134
Mercer, Thos. (Air Gauges), Ltd. —
Agency—Nigel Rainbow & Partners Ltd.
Microtechnica —
Midland Industries Ltd. —
Agency—A. A. Black Ltd.
Midland Silicones Ltd. 117
Agency—Roles & Parker Ltd.
Minganti & Co. —
Mirrlees, Bickerton & Day Ltd. —
Agency—Rowlinson-Broughton Ltd.
Mobil Oil Co. Ltd. 124
Agency—Masius & Ferguson Ltd.
Mond Nickel Co. Ltd. 1 & 161
Agency—T.G.A. Ltd.
Monks & Crane Ltd. —
Agency—Sandbrook, Metcalf & Co. Ltd.
Morgan Crucible Co. Ltd., The 40
Morris, B. O., Ltd. 171
Agency—Cogent Advertising Service Ltd.
Moulded Plastics (Bir'ham) Ltd. 116

Nash & Thompson Ltd. 74
Agency—Jas. Sutherland Publicity Ltd.
Neill, James, & Co. (Sheffield) Ltd. 25
Agency—J. K. Clayton Adv. Agency Ltd.
Newall, A. P., & Co. Ltd. —
Agency—Osborne-Peacock Co. Ltd.
Newall Group Sales Ltd. —
Agency—J. Peers and Associates Ltd.
Newbold & Bulford Ltd. —
Agency—Hatton Press Ltd.
Newton Chambers & Co. Ltd. 38
Agency—F. C. Pritchard Wood & Partners. Ltd.
Nitralloy Ltd. 166
Agency—Stanley D. Dickson
Nu-Way Heating Plants Ltd. 34
Agency—Sinclair Advertising Ltd

Opperman Gears Ltd. 47
Agency—Ripley, Preston & Co. Ltd.
Opperman, S. E., Ltd —
Agency—Erwoods Ltd.
Osborn, Samuel, & Co. Ltd. 63
Ozalid Co. Ltd. 130
Agency—Oatley Webster Ltd.

P.R. Motors Ltd. 57
Agency—A. A. Black Ltd.
Parker Engineering Co. Ltd. —
Parmiter, Hope & Sugden Ltd. —
Agency—Donald Macdonald (Advertising) Ltd.
Pioneer Oilsealing & Moulding Co. Ltd. —
Agency—Hyde & Partners Ltd.
Pitman, Sir Isaac, & Sons Ltd. 3
Pizzochero —
Podmores (Engineers) Ltd. —
Agency—Maurice & Parker Ltd.
Pollard Bearings Ltd. —
Agency—Hedley, Byrne & Co. Ltd.
Polypenco Ltd. 138
Agency—Anthony Handley Adv. Ltd.
Powder Couplings Ltd. —
Agency—Dryden-Allen Ltd.
Power-Gas Corporation Ltd. —
Price, J. T., & Co. Ltd. —
Agency—A. A. Black, Ltd.
Pye Electric Co. Ltd. 61
Agency—Arkes Publicity Ltd.
Pyrene Co. Ltd., The —
Agency—Nelson Adv. Service Ltd.

Quasi-Arc Ltd. —
Agency—F. C. Pritchard Wood & Partners Ltd.

Ransome & Marles Bearing Co. Ltd. 5
Agency—Ruddocks Advertising Agency
Rapid Magnetic Ltd. —
Agency—Ed. Hilton Advertising Ltd.
Refined Iron Co. (Darwen) Ltd. —
Agency—Stowe & Bowden Ltd.
Renold Chains Ltd. —
Reynolds Tube Co. Ltd. 164
Agency—Ripley Preston & Co. Ltd.
Richards, Charles, & Sons Ltd. —
Agency—Longleys & Hoffmann Ltd.
Richardsons Westgarth (Hartlepool) Ltd. 163
Agency—Notley Advertising Ltd.
Roberts, J. W., Ltd. —
Agency—Armstrong-Warden Ltd.
Robinson, L., & Co. (Gillingham) Ltd. —
Agency—Ripley, Preston & Co. Ltd.
Rockweld Ltd. —
Agency—John Mitchell & Partners Ltd.
Rockwell Machine Tool Co. Ltd. —
Agency—John Mitchell & Partners Ltd.
Rocol Ltd. 169
Agency—Nevin D. Hirst (Advertising) Ltd.
Rotameter Mfg. Co. Ltd. —
Agency—Geoffrey Dadd Ltd.
Rotherham & Sons Ltd. —
Agency—George Murray Advertising Ltd.
Royce Electric Furnaces Ltd. —
Agency—Nigel Rainbow & Partners
Rubert & Co. Ltd. —
Ryder, Thos., & Son Ltd. 11
Agency—W. S. Crawford Ltd.

S.A.I.M.P. —
Salter, Geo., & Co. Ltd. 62
Agency—Severn Publicity Ltd.
Sanderson, Bros., & Newbould Ltd. 170
Saturn Industrial Gases Ltd. 154
Agency—Crossley & Co. Ltd.
Saunders-Roe Ltd. 165
Agency—Stanley D. Dickson
Savery, Thomas, Pumps Ltd. —
Agency—Boswell, Barrett & Phillips Ltd.
Self-Changing Gears Ltd. 166
Serck Radiators Ltd. —
Agency—Longleys & Hoffmann Ltd.
Sheffield Twist Drill & Steel Co. Ltd., The 19
Slack & Parr Ltd. 160
Agency—Rex Publicity Service Ltd.
Smith's Industrial Instruments Ltd. —
Agency—Allardyce Palmer Ltd.
Smith, J. W. (Coventry) Ltd. 10
Agency—Don Earl Publicity Ltd.
Smith, S., & Sons (England) Ltd. —
Agency—Allardyce Palmer Ltd.
Soag Machine Tools Ltd. —
Solex (Gauges) Ltd. —
Agency—David Macauley Adv. Ltd.
Southern Instruments Ltd. —
Agency—Brandis Davis Agency Ltd.
Sperry Gyroscope Co. Ltd. 67
Agency—Samson Clark & Co. Ltd.
Standard Piston Ring Co. Ltd. —
Agency—H. C. Boulter Publicity Ltd.
Steel, J. M., & Co. Ltd. 166
Agency—Reynell & Son Ltd.
Stephens Belting Co. Ltd. —
Agency—Nicholls Dorrity Adv. Ltd.
Sterling Metals Ltd. 144
Agency—T. G. Scott & Son Ltd.

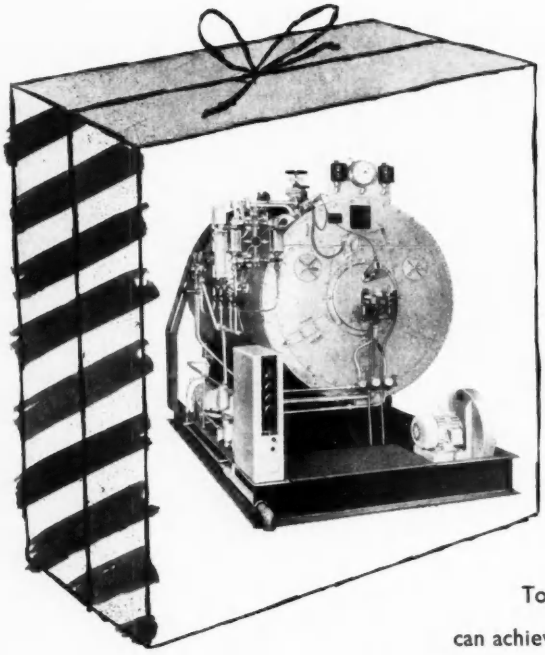
Stone-Wallwork Ltd. 49
Agency—Holman Advertising Ltd.
Super Oil Seals & Gaskets Ltd. —
Agency—A. A. Black Ltd.
Sykes, W. E., Ltd. 159
Agency—W. S. Crawford Ltd.

Tangyes Limited —
Taylor Bros., & Co. Ltd. 155
Technical Applications Ltd 126
Agency—Alfred Bates & Son Ltd.
Teleflex Products Ltd. 55
Agency—J. Peers and Associates Ltd.
Telehoist Limited 48
Agency—W. S. Crawford.
Tensator Ltd. —
Agency—G. P. Hughes Ltd.
Terry, Herbert & Sons Ltd. 132
Agency—John Haddon & Co. Ltd.
Thompson, John (Wilson Boilers) Ltd. 23
Agency—Rowlinson-Broughton
Thorp, Thomas, & Co. Ltd. —
Agency—J. Peers & Assocs. Ltd.
Thorpe, F. W., Limited —
Agency—S. D. Toon & Heath Ltd.
Titanium Metal & Alloys Ltd. —
Agency—Alfred Bates & Son Ltd.
Torrington Co. Ltd., The 60
Agency—Osborne Peacock Co. Ltd.
Tufnel Ltd. 118
Agency—Crossley & Co. Ltd.

Unbrako Socket Screw Co. Ltd. —
Agency—Nicholls Dorrity Adv. Ltd.
United Coke & Chemicals Co. Ltd. —
Agency—Rowlinson-Broughton Ltd. Co.
United Dominions Trust (Commercial) Ltd. —
Agency—St. James Adv. & Publicity Ltd.
United States Metallic Packing Co. Ltd. Cover 3
Agency—Wm. Furness Ltd.

Varatio-Strateline Gears Ltd. —
Agency—Thomas G. Birtles Ltd.
Varley, F. M. C., Ltd. 52
Agency—J. Peers & Associates Ltd.
Verein deutscherWerkzeugmaschinenfabriken —
Vickers Armstrong (Engineers) Ltd. 64
Agency—T.G.A. Ltd.
Victor Products (Wallsend) Ltd —
Agency—Doig Advertising Ltd.
Vigel —
Vokes Ltd. —
Agency—Trowbridge, Pritchard & Co. Ltd.

Waircom —
Wakefield-Dick Industrial Oils Ltd. —
Agency—Dorland Adv. Ltd.
Walker, Crosweller & Co. Ltd. —
Agency—Beardmore Advertising Ltd.
Walpamur Co. Ltd., The 66
Agency—Osborne-Peacock Co. Ltd.
Ward, H. W., & Co. Ltd. —
Agency—Associated British Machine Tool Makers Ltd.
Ward (Metal Details) Ltd. 164
Agency—Beardmore Advertising Ltd.
Weathershields Ltd. Cover 3
Agency—Oldfield & Sharp
Welconstruct Co. Ltd. —
Agency—Mundy, Gilbert & Troman Ltd.
Wellman Bibby Co. Ltd., The 146
Wellworthy Ltd. 128
Welsh Metal Industries Ltd. 174
Agency—Notley Advertising Ltd.
Wharton Crane & Hoist Co. Ltd. —
Agency—Henry Pybus Ltd.
Whitecross Co. Ltd. 6
Agency—Ripley, Preston & Co. Ltd.
Whitehouse Industries Ltd. —
Agency—Hedley Byrne & Co. Ltd.
Wicksteed & Co. (1920) Ltd. —
Agency—Nicholls, Dorrity Adv. Ltd.
Wiggin, Henry, & Co. Ltd. —
Agency—T.G.A. Ltd.
Wild-Barfield Electric Furnaces Ltd. 147
Agency—Crane Publicity Ltd.
Williams, John, of Cardiff Ltd. —
Agency—Glovers Adv. Ltd.
Winn, Chas., & Co. Ltd. 162
Agency—Sandbrook, Metcalf & Co. Ltd.
Wolverhampton Diecasting Co. Ltd., The —
Agency—Sterling Advertising Ltd.
Woodside Die Sinking Co. Ltd. —
Agency—F. C. Pritchard Wood & Partners Ltd.
Workington Iron & Steel Company —
Agency—Everett's Advertising Ltd.
Wragby Plastics Ltd. 96
Agency—Willsmore & Tibbenham Ltd.



This 'package' delivers 5,000 MILLION B.T.U.s daily!

(and brings real economy with it)

To say that the "Steampacket" package boiler can achieve almost anything doesn't mean it will climb up the wall (although its amazing performance will prevent you from ever doing so). This remarkable time-proven smokeless packaged boiler operates efficiently without supervision. It incorporates the best practice in boiler construction and it will certainly pay you to investigate further by contacting us to-day.

THE CRADLEY

'STEAMPACKET'

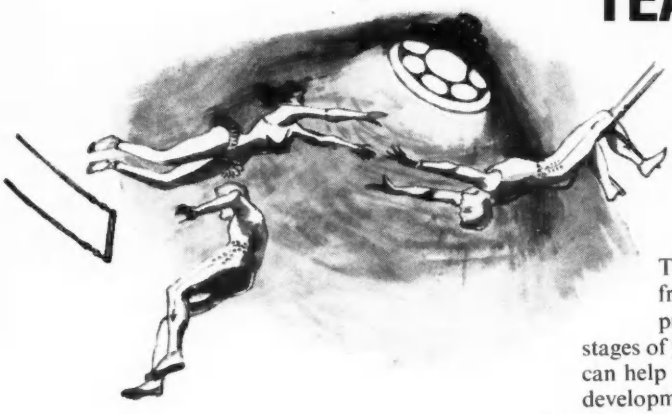
PACKAGE BOILER

(London) Laburnum 7962.
(Glasgow) Merrylee 0510.
Gatley 4761. Bristol 58887.
Gosforth 5-4654

THE CRADLEY BOILER CO. LTD.
CRADLEY HEATH, STAFFORDSHIRE
Telephone: Cradley Heath 66003

Branches at:
LONDON, BRISTOL, MANCHESTER AND GLASGOW

TEAM WORK



It's team work that counts—

Team work all the way through, from the inception to the finishing processes. In all the intermediate stages of your production, Weathershields can help you, by co-operation in design, development, manufacture and service to solve your bottle-neck problems and maintain maximum output. *Team up with Weathershields and keep things moving.*

Press Work, Fabrications, Assemblies, Sheet Metal Work, Welding, Glazed Units.

LIGHT ENGINEERING DIVISION **Weathershields LTD**

THE NAME YOU KNOW

BISHOP ST., BIRMINGHAM, 5. Tel: MIDland 5876

The 'BRADFORD' Power Cylinder
More power to your elbow with Bradford air or hydraulic power cylinders

Bradford Air Cylinders.
In standard sizes from 2" to 20" bore, with hand or remote control.

All-Steel Hydraulic Cylinders.
Standard sizes from 1½" to 12" honed bores, to work at pressures from 200 lbs. to 1,500 lbs. per sq. in. with hydraulic fluid, oil or water. Supplied as required, with bracket, clevis, trunnion or end cover mountings.
Bradford Air or Hydraulic Cylinders can also be made to customers' specifications with any length of stroke.

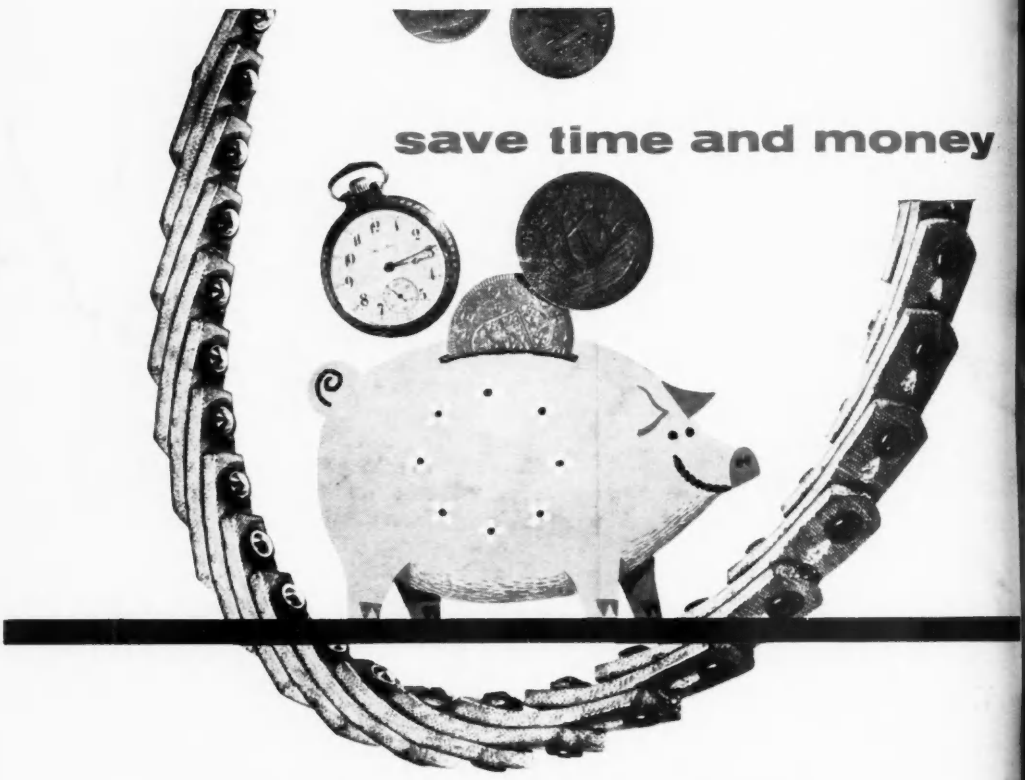
UNITED STATES METALLIC PACKING CO. LTD.

SOHO WORKS, BRADFORD 8, YORKSHIRE

U.S.M.P

Telegrams: "Metallic," Bradford. Telephone 41284-5.

Branch Offices: London, Liverpool, Glasgow, Manchester, Newcastle, Cardiff, Southampton, Hull, Swansea and Bristol.



WITH DIXLINK V BELT

Because DIXLINK is completely detachable and fully adjustable, because it can be used where pulleys are mounted between bearings or in confined positions, because it can be fitted to any length without having to design a standard centre distance, because there is no need to carry large stocks (one coil of the appropriate section will cover all requirements), because of a dozen other reasons, DIXLINK is the ideal V-belt drive for any and all types of installation. DIXLINK, like all other DICK products, is made from the finest quality materials, pure natural rubber, cotton duck woven to our own special specification and high grade steel studs. It is manufactured in various sizes covering the M, A, B, C and D rubber Vee-rope range in both 40 and 28 angle sections. DIXLINK is available in qualities that resist oil, heat and fire. Its performance is a source of satisfaction to all users. Contact our nearest branch for technical advice on all power transmission problems . . . today.

R. & J. DICK LTD.

HEAD OFFICE AND FACTORY
GREENHEAD WORKS, GLASGOW, S.E.
Tel: BRidgeton 2344 (5 lines) Grams: Guttapercha, Glasgow

For further information write for our latest Brochure

DICK

THE NAME WHICH MEANS DEVELOPMENT IN POWER TRANSMISSION

U.K. BRANCHES: Glasgow, London, Bristol, Birmingham, Manchester, Leeds, Newcastle, Dundee, Belfast and Dublin **EUROPEAN BRANCHES:** Amsterdam and Vienna
UNITED STATES FACTORIES: Totowa, New Jersey and at Muscatine, Iowa **BRANCHES:** New York, Chicago, San Francisco, Los Angeles, and Seattle
CANADIAN SUBSIDIARY: R. & J. DICK (CANADA) LTD., 2430 Fairview Avenue, Burlington, Ontario. Tel: Nelson 7/1851. **AGENCIES IN PRINCIPAL COUNTRIES THROUGHOUT THE WORLD.**